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RADIO AT WAR ..... Cover
Communications equipment in half-track armed with 50-mm mahine-gun. U. S. Army photo

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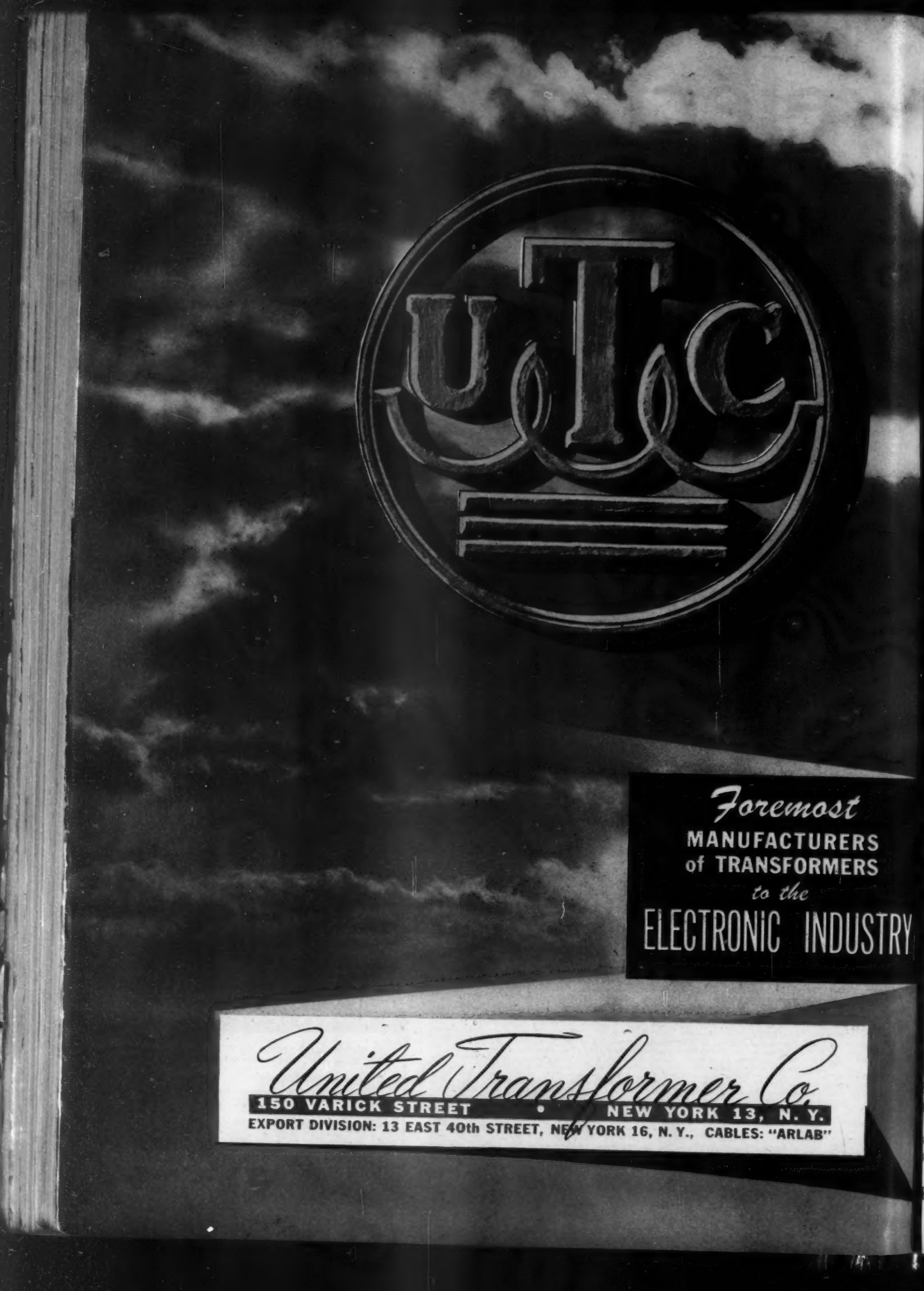
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WASHINGTON FEEDBACK

Post-War Frequencies—Prior to the outbreak of the war the FCC allocated frequencies to specific services only between 10 kc and 300,000 kc. Now, as a result of wartime developments, practical application of frequencies above 300,000 kc is receiving intensive study and the Commission is, in fact looking closely into the subject of frequencies much higher than 300 Mc.

It is recognized that whatever pattern for frequency allocation is set for the immediate post-war period may well govern for many years to come. It is also recognized that when the war with Germany ends, manufacturers will gradually start civilian goods production, and FCC desires to have a suitable control plan ready. If, for example, television bands are to be changed, such changes should obviously be accomplished before production of new equipment begins.

At present, 18 channels totaling 108,000 kc have been assigned to television. FCC Chief Engineer E. K. Jett stated recently to an editor of ELECTRONICS that he was not personally satisfied that 18 channels was adequate for a nation-wide competitive system of television broadcasting. He also expressed some doubt as to whether a television channel under standards should be only 6000 kc wide, particularly if FM is to be used for video transmission as well as for the sound track.

There has been a question of whether or not to keep FM on its present bands. FCC field offices are now making continuous recordings of FM stations to provide data concerning long distance interference, interference from the E layer and sporadic bursts from the ionosphere. Some engineers feel that FM should go higher in frequency.

Some ultrahigh bands will be necessary after the war for new services such as anti-collision devices, and must be relatively free from interference. Every commercial airplane may carry such a device. Because of the importance of them from the safety standpoint, FCC has asked the CAA and CAB to review the requirements of aviation after the war.

After a domestic pattern for post-war allocations has been worked out, it will be necessary to arrive at some sort of international agreement. For instance, it is altogether possible that this country might use a certain band for anti-collision work and another country might use it for television. It will also be necessary to take into consideration that important developments may be held in secrecy by the services even after the war and may require frequencies.

Whatever changes may be advisable, FCC officials have indicated that Standard Broadcasting and International Broadcasting frequency allocations will remain "as is" after the war.

Circulating Component Inventories—In the works in Washington is a program of specific aids designed to make it easier for the electronic field to meet current equipment demands and the greatly expanded production schedule for 1944. This program is directed at the bottleneck of components, which is considered an even greater factor in production lags than all the other factors, not excluding manpower shortages and changing military requirements.

Two major operational changes are contemplated. First, there will be a report to WPB's Radio Division of all existing inventories of components and then a circulation of the needed components among manufacturers with WPB guaranteeing restitutions and underwriting costs of circulation. Second, there will be brought about a much closer liaison and working relationship between ANEPA — Army-Navy Electronics Production Agency—and WPB.

Under the circulation of inventory plan, Sidney K. Wolfe, Assistant Director for Production of the Radio Division of WPB, will get a complete report of inventories from prime contractors and set it up under two parts —dead inventory and live inventory. Generally speaking, in the dead inventory will be components made for equipment no longer produced; in the live inventory will be components going into current equipment.

The agencies operating through ANEPA have heretofore thought largely in terms of completed units of equipment rather than in terms of components. As a result, it was oftentimes only after a serious lag in schedule fulfilment had developed that the cause was brought to the attention of WPB's Radio Division officials. The various formalities, including directives, priorities, etc., consumed more time and extended the lag. Under the new plan, 22 members of ANEPA will be transferred from the War Department to the WPB Radio headquarters, where they will work with the Radio Division for the primary purpose of anticipating demands for components and making timely provision for materials and manufacturing.

New Army Network—Domestic wire communications of the Army are being consolidated into a single system. The new system, known as Army Command and Administrative Network, Army Service Forces, is being set up under the supervision of Brig. Gen. Frank E. Stoner, Army Communications Service of the Signal Corps. When completed there will be 25 message centers in operation, including Army Service Commands, and 15 or more additional points close to important military installations.

Radio circuits for overseas communications will be continued. Certain communication systems of Army branches which require specialized traffic handling, such as Army Air Forces, will also be continued, but it is planned to connect the new network with specialized nets of these other branches so that traffic can be transferred. Trunk circuits will connect various message centers and specialized relay equipment will be installed to speed operations.—G.T.M.

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CROSS TALK

▶**WAR . . .** Despite pessimistic statements from some men high in authority that the war will last much longer, there is much speculation and some betting that it may end sooner than we now think. The dope, according to some experts, is that Germany will fold up in Spring or Summer of 1944—not licked by force of arms but convinced beyond any doubt that the longer she fights, the poorer the settlement received at the peace table.

These dopesters agree that Japan will be knocked out a year later. No matter how correct or otherwise these seers are it seems certain that the approach of the end of the war with Germany will see a major change in the fighting equipment required. European war is land-army war and the equipment needed is vast quantities of planes, guns and land vehicles. Asiatic war seems bound to be more of a war in the sky and at sea and the equipment required will be vast quantities of planes, and ocean-going vehicles.

Of course, both wars will continue to require the manufacture of signal and other electronic apparatus in prodigious quantities. If the war ends in Europe, communications apparatus will still be necessary to get things going again. As the war continues in Asia, communication and control apparatus to cover the vast Pacific void will be necessary.

Thus it seems unlikely that large-scale cancellations of contracts for aircraft or electronic apparatus are anywhere in sight as yet, for these two types of equipment are indissolubly connected together.

▶**IGNORANCE . . .** A survey recently conducted to determine the chief pre-war reasons for the slow acceptance by industry of electronic principles disclosed a remarkable unanimity of opinion. "Lack of knowledge" of the possibilities of electronic apparatus was rated as the Number 1 stumbling block. This was stated in several ways; thus, "Ignorance of the practical applications," or "industrial men do not realize the possibilities."

Thus it is especially fortunate that in many industrial companies, courses in electronics are now being formed to educate plant superintendents, electrical engineers, and production men in the elements of tube equipment. The magnitude of the education job that must be done can be realized from the fact that an electron tube to the average power electrical engineer is a definite open circuit. He knows that something happens between cathode and anode across the evacuated space, but it does not seem quite proper to depend upon it.

▶**EDUCATION . . .** End of the war will undoubtedly see some change in our educational system, just as the termination of the last conflict reacted upon our colleges and high schools. For example, Latin has never been the subject it was prior to the last war. Teachers went away; Latin had to be simplified so new teachers could instruct students in the subject—and present-day Latin courses and books still show the results.

Already courses are being prepared for the demobilization days. Men who have the requisite educational background or the ability to learn will be given opportunity to complete work for degrees. Already educators, borrowed by the armed services for educational programs during the war, are learning the joys of teaching men selected according to their ability to learn.

Who knows but that those who return to college will find classes no longer heavily charged with rich but dumb youngsters whose social or economic standing overshadows their educational interests or possibilities.

▶**VECTORS . . .** Many a radio man having poohpoohed vector analysis all of his life is now convinced that he must learn something about it or be out of the swim after the war. It is certain that the most casual reading of any of the modern books dealing with radiation or wave guides will abruptly change these engineers' opinions as to the value of this powerful mathematical tool.

It is with considerable pleasure, therefore, that ELECTRONICS finds that it now knows what a vector is. A vector is the technical name for "those species of mosquitos which transmit the germs of malaria from human carriers to infect other humans."

NOW
Is The Time To St

A lot of things make it difficult to standardize on one set of electronic equipment component parts symbols for the communications, power and control fields, but the old democratic principle of "most good for the most people" would be well served by such standardization. It will never be easier to accomplish than today

FOR SOME TIME it has been apparent that two large groups of engineers (communications and industrial control) using electron tube apparatus were tending to perpetuate a situation now existent regarding the different symbolic language they employ to represent certain important identical pieces of apparatus.

This situation has been commented upon several times in ELECTRONICS and considerable correspondence has resulted between the editors and engineers familiar with attempts to standardize symbols.

The results of much effort on the part of ASA committees representing communications and power groups have been published in ASA bulletins Z-32.5 and Z-32.3. These publications indicate that agreement on all but four important symbols is now possible, but that agreement on these four has not yet been attained.

Unfortunately, the four symbols referred to must be employed in practically every circuit diagram since they represent components used in all electronic circuits.

The "trouble-makers" at present are symbols for resistors, capacitors, contactors and inductors.

Questions, And Answers

Certain points which have come up in correspondence with the editors on this subject will be reviewed, in the hope that power and communications engineers will see that *now* is the time in which our symbolic language should be standardized, if such is ever going to be possible. These points are as follows:

1. *There is some feeling that* ELECTRONICS *is "over-emphasizing the importance of entirely reconciling the power, control and measurement symbols with the communication symbols, inasmuch as there is only a limited amount of overlapping between these two fields of endeavor. Examples of this overlap might be the limited field where carrier on power lines enters into high-tension power line development, and also, to a limited extent, where power control in airplanes may concern the same people who build or use the communications equipment in these airplanes."*

There is no doubt that the overlap between the two fields has so far been slight; but this overlap is now increasing at an extremely rapid rate. For example, a whole book has just been published which treats of electronic control circuits for welding. This book uses power symbols. One of the most active of all industrial-electronic fields has been welding control. The next big phase of development is already well started—the control of d-c motors operated on a-c lines. Both of these fields use electron tubes very widely, and naturally employ symbols for the four components on which there is as yet no agreed representation.

Since the present overlap is still small but is growing rapidly, *now* would be the ideal time for the communications and the power people to get together and to agree upon a single set of symbols.

2. *"There is a background of 40 to 50 years of usage in both communications and power fields, where little effect of the non-standardization of conventions has been felt."*

There are good reasons why power, measurement and control people have developed four symbols which differ from those developed by communications people. There are perfectly natural reasons why each group should prefer not to change its long-established conventions in favor of new conventions, whether these happen to be the representations employed by the other group or totally new symbols.

This fact notwithstanding, different symbols are not in the common interest, thinking of the industry as a whole, and something should be done about the situation *now.*

3. *It is felt by some who have been working on the ASA committees that the present standards are "the best that can be evolved at the present time."*

This may be so; but it is also true that it will never be any easier to evolve a uniform system. Every year that goes by will see greater difficulty, in fact.

Standardize SYMBOLS

At the moment, there is much interest throughout industry in the general subject of electronics. It is certain that the war has brought much greater use of electronic circuits into industrial consciousness and in actual use. This interest in industrial (non-communication) electronics is, at present, crystallizing in the form of company classes in electronics for engineers of all kinds so that they will be able to apply electron tube apparatus to individual processes or products, or to know what can be purchased on the market to do various jobs and how best to use it.

Some of these classes will be taught by radio engineers and it is only natural that they will use their own familiar symbols; other classes will be taught by industrial control engineers and in these classes it is certain that the industrial symbols will be taught. Thus the present divergence will be still further solidified if something is not done about it *now*.

4. *An important "deterrent to agreement on a uniform set of graphical symbols is the cost of making changes in drawings and records."*

ELECTRONICS does not believe that the many thousands of drawings already in existence need be changed to conform to a new set of standards. Certainly the cost of such revision would be terrific and not worth it. But if an agreement could be reached on future drawings, ultimately all new drawings would conform to modern symbolic practice.

Thus the future situation would be cleared up by action *now*.

5. *"Standardization is a slow process and while we will undoubtedly get further along toward a uniform set of symbols, it will take a long time."*

There is no argument about the fact that it takes much time and effort—dull, dreary, time-consuming and often thankless work on the part of committee members—to effect any program of standardization. The work accomplished by the men who serve on standardization committees is seldom appreciated by the industry which benefits from this work.

There is no labor less inspiring than service of this kind, never spectacular, always representing time taken from the worker's busy days and nights. Certainly, in any industry nothing is more to be commended than the steady grind put in by its standardizing zealots.

But time moves on; and each day will only add to ultimate confusion. Certainly the most economical time to get together on the four common symbols causing the most trouble is *now*. Later, if standardization is not accomplished, engineers will have to learn not two sets of symbols but three—their own, the other fellows' and new ones.

THE FOUR CHIEF TROUBLE-MAKERS

NAME	POWER	COMMUNICATIONS
Contactor	Open / Closed	Open / Closed
Resistor		
Inductor Air core Iron core		
Capacitor		

Suggestions Are Welcome

Other comments of interest and value from the heavy correspondence on this vital matter will be covered in future issues of ELECTRONICS—but at the moment its editors hope that their belief that the time to effect standardization is *now* will be shared by both power and communications engineers.

ELECTRONICS would be most happy to have several sets of proposed symbols to present to an early meeting of the ASA committees—and of course the committees themselves would be happy to receive any such suggestions sent directly to them via the American Standards Association, 33 West 39th Street, New York.—K.H.

in the JEEP

By
FRANK E. BUTLER

it was first tried, proving its ability to traverse tortuous jungle paths and skim across hastily prepared pontoon bridges which were closed to other types of cars and trucks because of their size and weight. It was then assigned to offensive operations, where it has effectively leaped into the breach of virtually every military land movement.

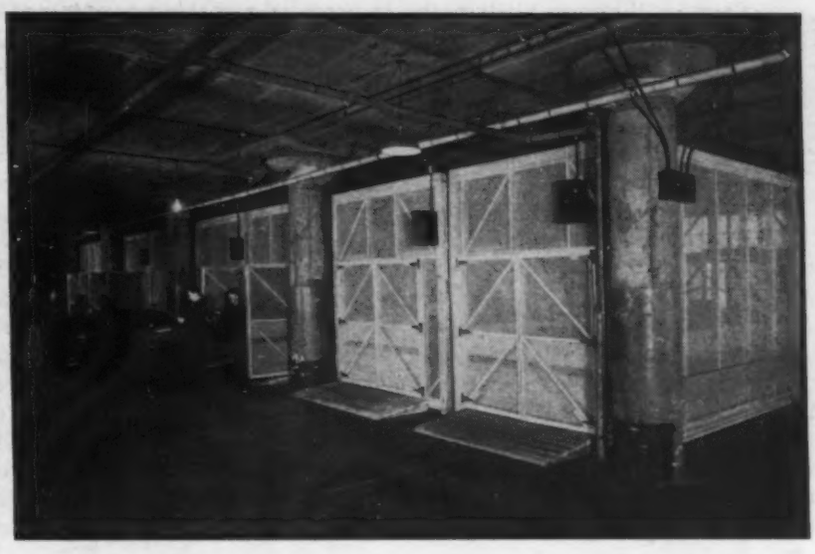
As an offensive weapon, the Jeep has surpassed even its defense record. Much of its success may be attributed to the fact that it is equipped with the "eyes and ears of radio."

Approach to Problem

Because the Jeep was primarily the creation and development of Willys-Overland Motors of Toledo, Ohio, this firm was the first to be called upon by the armed forces to tackle the problem of suppressing electrical interference generated by an operating automobile engine.

Three major problems had to be overcome:

(1) There existed no satisfactory available noise measuring instruments for determining the effectiveness of suppression equipment, so suitable



Typical test cages. A marker board for front wheels stops all cars at the same place. An easily attached hose removes exhaust gases and one may be seen on the floor at the left in the closeup. Power line filters are at the upper right, outside each booth or cage. Permanent test equipment within each cage includes a transmitter, a receiver and noise-indicating apparatus

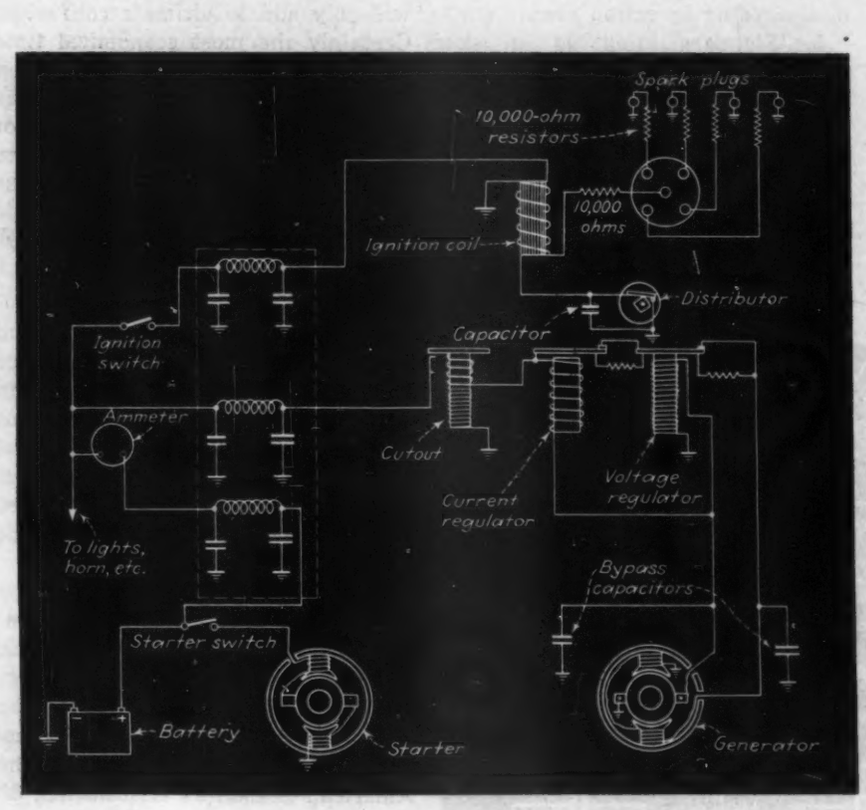
Suppressing Radio Noise in

Interference created by the versatile little car's own electrical equipment, or that of other nearby machines, is minimized by means of careful body bonding, standardized filtering and thorough tests as mobile units leave the assembly line

BEFORE PEARL HARBOR, cars were widely sold to the general public but the problem of suppressing electrical interference which radiated from the spark plugs of the automobile engine, the generator, the distributor head, the voltage regulator and other points was one that had not been seriously attacked nor completely solved.

The few so-called built-in suppression ideas then used represented the sparse efforts of the individual automobile manufacturer. Likewise, every radio serviceman had his own pet scheme for solving this general problem and each suppression job differed in some way from all the rest.

As a consequence, there existed no established standard of practice covering all types of auto-electrical parts. Aside from the difficulty of reception in cars themselves, short-wave reception was frequently spoiled when automobiles passed within reception range of receivers in homes along busy roads.



Jeep radio noise suppression filtering scheme

Wartime Design Requirements

The exigencies of the war quickly changed this state of affairs. Among the scores of new demands upon industry was a call for widely diversified types of motor transportation that could be equipped with high quality radio apparatus capable of maintaining two-way uninterrupted communication between rapidly moving, closely packed mobile units, at all times . . . and under operating conditions such as had never before been encountered or anticipated.

One of the innovations produced as a result of this need was the Jeep, which was primarily designed as a reconnaissance car . . . something light in weight and speedy; something that could go anywhere through tight, cramped places. Not only did the Jeep quickly answer these requirements but it at once established itself on every fighting front as the most verstatile of all motorized units used by the armed forces.

The Jeep demonstrated stellar performance in defense action, where

filters are placed in the lines from the primary of the high-tension coil to the ignition switch, from the ammeter to a terminal of the voltage regulator and also from the ammeter to the battery. A 10,000-ohm resistor is mounted in series on each of the four spark plugs. Another resistor of the same value is inserted between the distributor head and the ignition coil. Capacitor-type filters are placed from the generator armature terminal to ground and from the regulator field terminal to ground.

Detailed electrical values of the component parts of the filters are not at the present time publishable. These parts are combined in a waterproof container on the driver's side of the dash.

It is found, in practical operation of the Jeep, that the condition of the distributor head is responsible for much of the noise and interference, hence it is important that breaker points and distributor gaps are set within certain limits. Proper timing also is effective in reduction of spark interference.

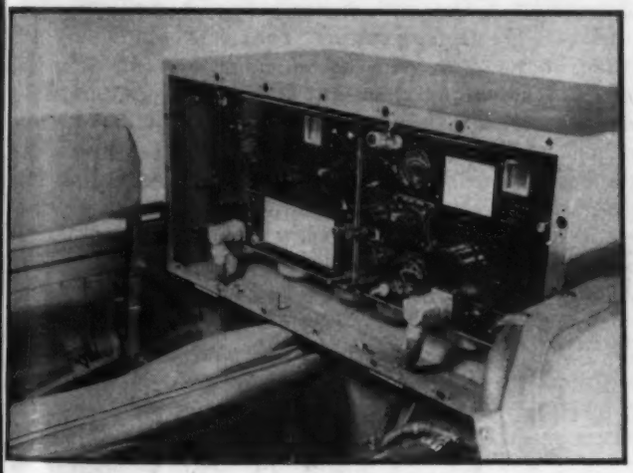
Looking forward, protective covers removed from communications gear

Noise Test Procedure

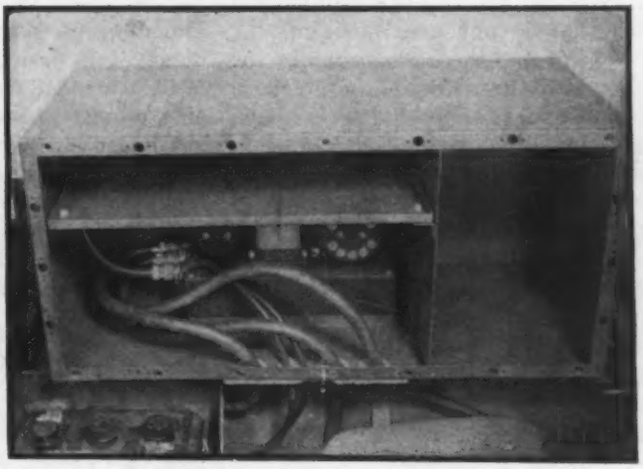
The installation of the suppression equipment is performed on the regular motor-car assembly line. After the Jeep is run off the final assembly it is given a thorough radio interference test in a specially-shielded testing booth. This booth is about the size of a small garage, with doors opening at its two ends. Engineers check each installation for output in milliwatts under three different conditions; first with the car motor off, then with the motor idling and, finally, with the motor running at about half maximum speed. Noise is then checked over a series of wave bands ranging from 0.5 to 30 Mc, in from 11 to 21 tests. Each frequency reading must pass within certain defined limits, otherwise the job is rejected and is run aside for re-adjustment, after which it is again rechecked.

Many shielded booths are in service in the plant, and each one is supplied with individual testing equipment, located only a matter of inches away from the active, operating vehicle.

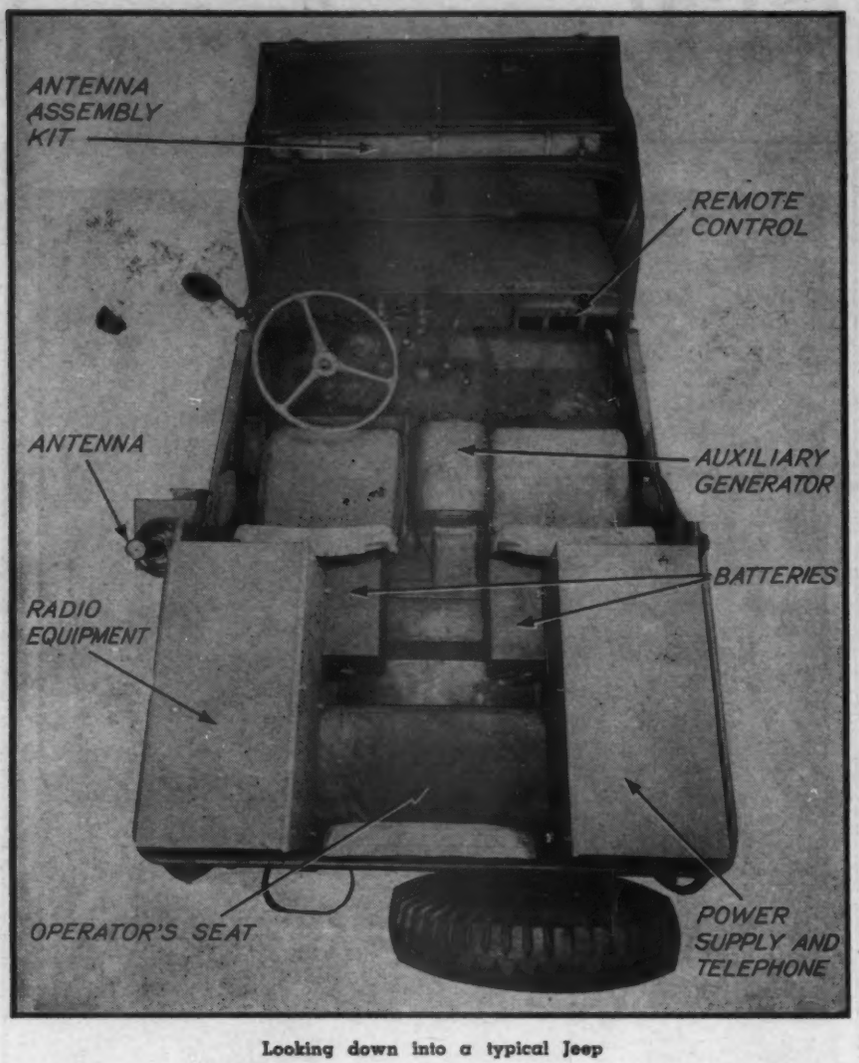
Augmenting strict tests, finished Jeeps are frequently picked at random from the end of the line and given a practical road or field run.



Closeup of radio equipment, with receiver at the left, transmitter at the right



Closeup of power supply compartment, with room for a field telephone



Looking down into a typical Jeep

test gear had to be created first.

(2) There was no engineering group within the Army, the Navy or the auto plant with an accumulated wealth of technical data on the specific subject of electrical noise suppression, so it was first necessary to gather such data from every conceivable source.

(3) There was no standard suppression system design in existence.

Typical Communications Gear

Inasmuch as the Jeep is often required to plow through hot desert sands or travel through mud, ford shallow streams or wallow across swampy land and smash through underbrush, its vital radio equipment had to be installed in specially cushioned and waterproofed compartments. Remote control, permitting operation of equipment without opening these compartments, also had to be provided and this was obtained by placing a small sub-control box in the conventional glove compartment on the dash board, at the right of the driver.

The radio antenna had to be small and relatively inconspicuous to conform with the low, hard-to-spot silhouette of the car.

The radio equipment installed in a Jeep may be designed for either telephone or cw service and may require a 6, 12 or 24-v source of direct-current supply. An auxiliary shielded generator mounted on the floor of the car between the two front seats permits re-charging of the required batteries whether the vehicle is stationary or in motion. This generator is an air-cooled, 55-amp, four-brush type provided with a three-unit regulator consisting of a cut-out relay, current-limiting regulator and voltage regulator. Voltage is not allowed to reach a value at which there is overcharging of the battery. The current regulator limits maximum generator output to 55 amp.

Interference Suppression Methods

Of special importance in electrical interference suppression on the Jeep is the thoroughness with which all metal parts of the automobile body are mechanically and electrically bonded together.

The frame, fenders, exhaust pipe, engine and all individual parts that are bolted or otherwise fastened together are securely connected by tinned surfaces. Every bolt of importance is supplied with internal and external-tooth lock washers, cadmium plated in order to obtain the lowest possible electrical resistance at points of contact. To accomplish the required perfection of electrical connections and security of parts there are approximately 40 separate tinned spots, including 19 bond straps, on each Jeep.

The interference suppression proper, aside from the perfect bonding and grounding methods, employs a three-section filter unit. Each section consists of a coil in series with the line to be filtered and two capacitors across the line to ground. Such

Jeep antenna box, showing loading coil which may be adjusted from outside

POST-WAR TELEVISION

A broadcaster * speaks his mind concerning the technical and economic status of the art, analyzes some of the plans proposed for its future development and makes several definite recommendations aimed at realistic cultivation of the coming market

By WORTHINGTON MINER *Manager of the Television Department*
Columbia Broadcasting System
New York City

ready approached its practical maximum; there seems little choice, therefore, but to consider some form of projection. Projection will inevitably demand greater definition. This leads to the second point.

(2) *The picture is not clear enough.* Any number of factors, some of greater, some of lesser importance, are involved in the clarity of the television image. Basic, of course, is the problem of lines, and the problem of lines is rigidly related to an equation involving the band width of the carrier. It is impossible, therefore, to consider any formidable increase in the line definition of the image, without considering the possibility, as well as the advisability of expanding the present 6-megacycle band. (The focus of the cathode-ray beam, the stepping up of the contrast range, these and many other factors contributory to the over-all clarity of the picture, are subsidiary to the basic problem of line structure.)

(3) *The picture lacks color.* The advantages of color, compared with black and white, are well-nigh inestimable. Color is, of itself, exciting. It adds immeasurably to the clarity of the picture. It is, moreover, intrinsic to the validity of a reportorial medium,—a medium which undertakes to bring spontaneous actuality into the home of the public. A vital part of every living scene is color, and a great share of its immediacy and reality is lost if color be subtracted. Television, without color, must walk with a crutch.

(4) *The picture is not reliable enough.* Almost every television receiver, no matter where it be located, is subject to some form of interference,—diathermy, traffic, high buildings, etc. Interference in the form of reflections, if they do not destroy, at least seriously hurt the image. The public will continue to be impatient with unreliable reception, until it is overcome. The answer in this case is not open to public discussion at this time, but there is reason to believe that important steps have already been taken along the road to more reliable reception.

(5) *The price of receivers has been too high.* This is a complex problem, since it is quite possible that the cost of receivers could be reduced more rapidly, if none of the available and, in many cases, vital improvements were incorporated. This reduction would, however, be temporary and comparatively small. A few independent manufacturers of receiving sets might, by sticking to pre-war standards, make some quick money in the interim; but in the long run it would be neither to their advantage, nor to the advantage of the public, nor to the advantage of television. In the long run, a complex but efficient receiver could be sold for less, and at a greater profit, to five million people, than a simpler design could be sold to five thousand. Mass production, which means mass demand, is the dominant factor in reducing the cost of receiver sets sold to the public.

Too Many Close-Ups

If these five shortcomings have seriously affected the public's response to television at the receiving end, they have quite as critically handicapped the producer of programs in the studio. The size of the screen provides a good example.

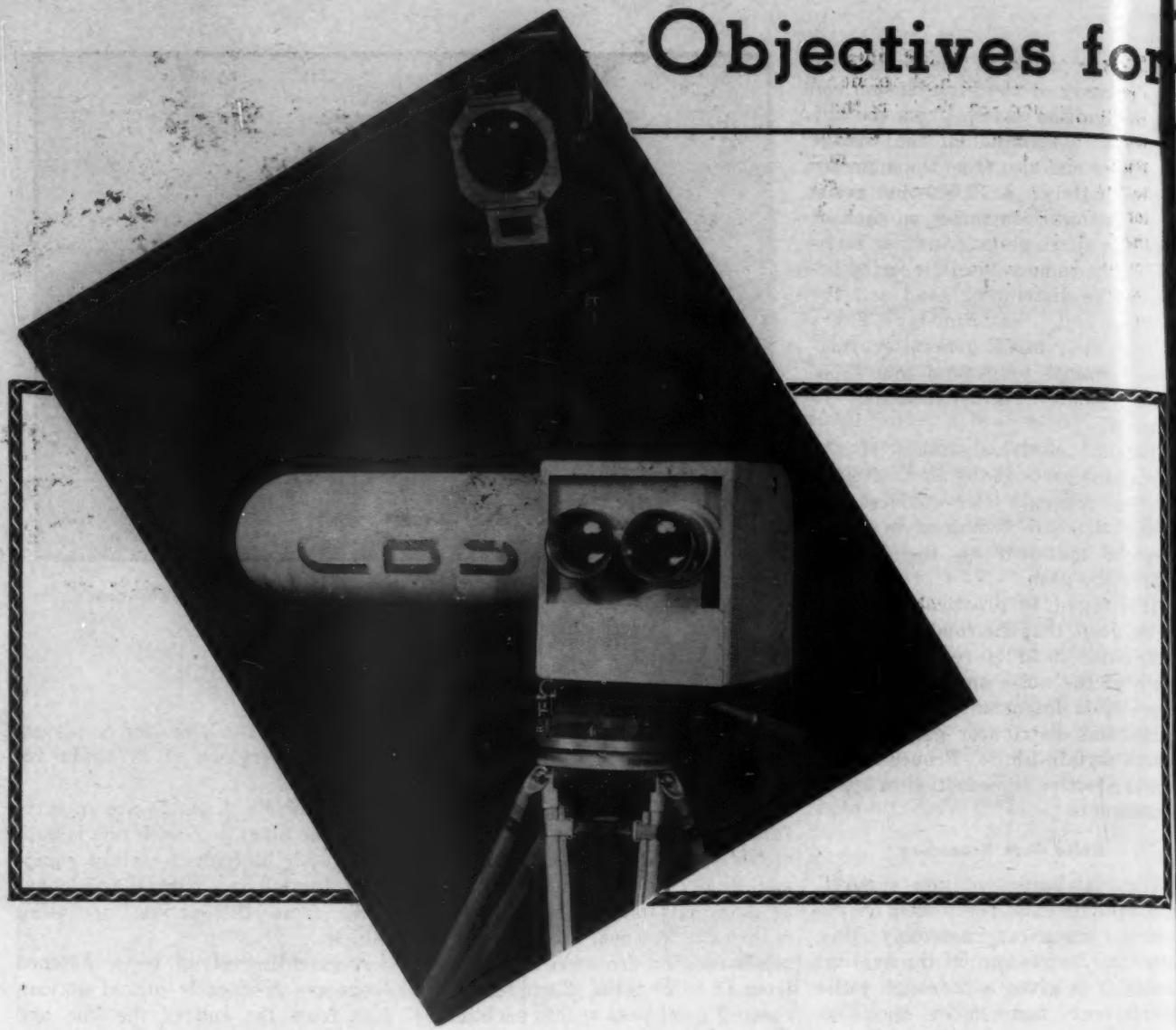
One of the basic obligations imposed on a producer of programs is to establish recognizability of the subject, whether that subject be a matchbox, a painting, or the face of a person. As a result, and against his deepest desire, the average director is forced, with the present screen size, to employ a mass of close-ups in series, no matter how inept, how inartistic, or how ineffectual he may

***A BROADCASTER** views television as a new and exciting method of bringing drama, news, education and the whole field of entertainment into the homes of the nation.

HE cares not what type of equipment is used. He wants, simply, a system by which the greatest possible public demand may be created and expanded.

HE has an objectivity toward the technical aspects of television which is impossible in a manufacturer with substantial investments in some specific system or design.

Objectives for P



DURING the past twelve years, television has made three abortive attempts to arouse a genuine and wide-spread public enthusiasm.

The first of these was begun by the Columbia Broadcasting System in the summer of 1931; the system, known as the "flying-spot", was inadequate and was abandoned in 1933. In 1939, the National Broadcasting Company, Don Lee, etc., went on the air with a regular schedule, using the electronic system of television pick-up and reception. In July of 1941, CBS, NBC, and others went on the air with regular programs of fifteen hours per week, using the same electronic system with certain improvements in standard.

Each of these attempts was made to an accompaniment of glowing promises; each failed to enlist much public support. The sale of sets during the last eight months of 1941 fell far below the expectancy of the industry; less sets, in fact, were sold during this period than in the year 1940, when television was hobbling along under the constant threat of obsolescence. At no time in the past twelve years has there been an insistent enough demand for receivers to reflect a genuine public enthusiasm for television. In its place, there has actually been public apathy.

What Is Wrong

The only way apathy can be dispelled is to create an insistent public demand for television programs. Before this can be achieved, however, there are certain minimal public demands in terms of technical efficiency, which must be met.

The best studio production is sterile, unless it can be translated into an acceptable image on the home receiver. The shortcomings of the present television system, from the viewpoint of the broadcasters,* can be summarized as follows:

(1) *The image is too small.* All the elaborate phrases regarding subtended angles have failed completely to affect the public's acceptance. It gets a bigger picture at the Music Hall. It gets a bigger picture on its home movie projectors. It wants a bigger picture, and that is that. It is not necessary to define how much bigger the television picture should be; it is enough to say that it must be bigger, for with acceptance of that fact, the main issue immediately emerges. The size of the television receiving tube has apparently al-

pile another abortive attempt upon those which have already occurred might well defer public acceptance of television for an indefinite time.

Analyzing Post-War Plans

Those who, before the war, worked close to television were profoundly disquieted by television's shortcomings. The dearth of skilled engineers, and the difficulty of incorporating even minor changes in the established standards without dismal and prolonged periods of shut-down, opened up a vista of many years of faltering and indeterminate progress, threatening to burden television with a well-nigh intolerable load of accumulated losses.

The war, by impelling a period of forced quiescence in programming, while simultaneously stirring up a vast undercurrent of inventive energy in the technical laboratories, has supplied television with its golden opportunity. After twelve years of incubation, television is now living through a period of hibernation, but behind this shell of inertia the dominant characteristics of television for the next twenty-five years are being shaped. The mask of tranquility covers a deep internal disturbance. In electronic terms, we are living through a revolution which may well open the door to an actual land of promise, in place of that shadow of a promise we have known before.

On the other hand, television cannot wait ten years till every refinement is brought to perfection. Far too much pressure from both inside and outside the industry will demand the re-emergence of television within a comparatively short period of time. What television needs, therefore, is not perfection in every detail. It needs a set of standards, broad enough in scope to allow for extensive technical improvements, free from the constant threat of wholesale obsolescence.

Conclusions

In the light of this proposal, let us re-examine the minimal demands of both the public and the producer of programs.

A larger picture demands greater definition; greater definition demands a wider band width; wider band widths are available in the higher frequencies. Color demands a wider band width, which, in turn, implies a transfer to the higher frequencies. Much of the danger from diathermy and traffic interference will disappear in the higher frequencies. The price of receivers is responsive to mass demand, and mass demand is directly stimulated by an increase in the quantity of stations in operation; there is infinite space for channel allotments in the higher frequencies. To effect this fundamental change will not demand ten years of stagnation.

Color intensifies the dramatic impact of television

Two basic propositions are cornerstones to the structure of a realistic post-war attitude.

(a) Television, under present standards, is not good enough.
(b) It can be good enough (and very quickly), if we do not wantonly dissipate, but use intelligently, the advantages the present hiatus affords us.

None of the necessary improvements, changes, or refinements is any longer shrouded in a misty future. All the basic inventions and research, upon which the solutions rest, are either completed, or approaching completion.

This is the supreme opportunity which the war holds forth to television. We can operate in the higher frequencies. We can have an increase of band width. We can, as a result, have a larger picture, a clearer picture, and we can have color. We can make more channels available, and that means we can improve television's ultimate service to the public. Above all, the moment military necessities permit, skilled man power, expanded laboratories and manufacturing facilities, all will be available to do the job.

Since certain basic changes in standards and in equipment have to be made, they must, at all costs, be made before television again emerges from obscurity. To gamble a fourth time with the public's good-will is to risk a permanent public disillusionment. So many glittering predictions have already been made, so great an expectancy has been aroused, that to plunge into the future on the rickety chassis of a model-T is inviting disaster.

Never again will there be an opportunity to create so revolutionary a change in so short a space of time at so small a cost. If this opportunity be thrown away, or sacrificed to the evanescent advantage of a fitful spurt in set sales, it will be a most tragic loss. It may well be a fatal loss.

feel them to be. He is left no choice. Even a waist-shot of the average person is inadequate to the establishment of individuality.

To develop a fluent and professional technique in the production of television programs, an increase in the size of the image is mandatory.

If color be desirable to the public, to the producer of television programs it is manna from heaven. Not only does it intensify the dramatic impact of the medium, but it opens up, at the same time, an extensive new field of program potentials.

Sporting events may be covered in black and white (though the color of the jockeys' silks and the players' uniforms is a vital adjunct to good reporting); without color, fashions can scarcely be covered at all. With color, moreover, the whole field of education is enriched. Botany, geology, the study of birds, and the study of chemical reactions in the laboratory are totally dependent upon the presence of color.

In the world of art, color is obligatory. And, if television is to survive through its power as an advertising medium, the addition of color will augment its selling value many times over.

Sports Pick-Ups Handicapped

A further factor, only indirectly appreciated by the public, but directly affecting the producer of television programs, is the stepping up of the sensitivity of the pick-up tube.

Under present light requirements, a vast amount of fine television material is made unavailable by the impossibility of securing adequate light. All through the fall and spring, late afternoon sporting events are dangerous to schedule. Interior pick-up with remote equipment (except under controlled conditions) is well nigh impossible. All this would be changed were the sensitivity of the pick-up tube increased.

Even within the studio itself, a reduction in the quantity of required light would notably lessen the problem of program production, would reduce complexity, the strain upon the performers, and the actual costs of operation.

We know now that television cannot be sold on the basis of novelty alone. It cannot be emphasized too often that the public, as a whole, will only buy television, its receivers and accessory equipment, because it wants to tune in on television programs; and it is axiomatic that the test of program acceptance is made, not in the studio, nor in the laboratory, but on the receiver in the home.

Novelty Alone Won't Sell Sets

When the motion picture industry began, it had nothing to compete with but the rotogravure sections of the Sunday papers. When radio began, it had nothing to compete with but the telephone and the trans-Atlantic cable. When the automobile began, it had nothing to compete with but the horse.

Television is less fortunate. From the moment it toddles out of its experimental play-pen, it must face a tough, two-pronged competition,—motion pictures and radio. So long as technical weaknesses impede the production of programs, reduce their effectiveness, or limit the scope of their appeal, television will remain in swaddling clothes.

Mass Demand Is Essential

Even with the optimum in technical development, the producer of television programs is still faced with a mountainous problem in dollars and cents. Television programs are expensive,—so expensive that a broadcaster, if he is to justify his presently accumulating losses, must see some point, in a not too distant future, when income will equal outgo. For the manufacturer of equipment, the break-even point might occur simultaneously with a negligible percentage of public acceptance. The sale of a few hundred, or a few thousand luxury sets per year could conceivably represent a profit to an astute manufacturer. For the broadcaster, however, the break-even point must await a wholesale public demand for television programs.

This mass demand is the ultimate aim, not only of the broadcaster, but of all elements of the television industry. Thus, it would be far less astute for the industry to endorse a graph rising sharply to twenty-five percent acceptance in a year or so, but falling off thereafter, than to endorse a graph showing no acceptance over a brief period of intensive technical readjustment, but a full acceptance in, say, seven years.

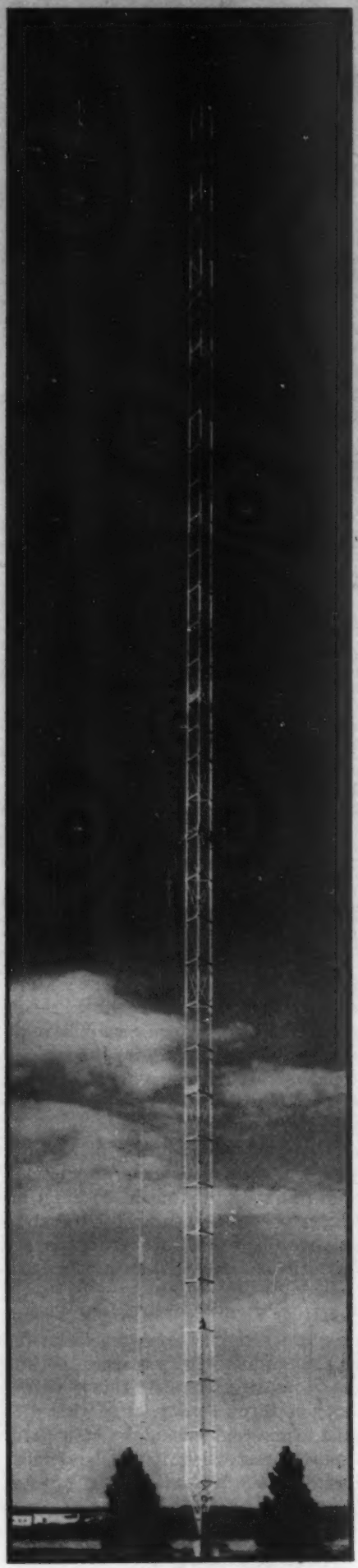
Too much of television thinking is concerned with achieving that rapid gradient up to the first twenty-five percent of acceptance, without fully considering the possibility that such a rapid rise may, of itself, be indicative of a fatal weakness. It may be the product of hard selling, of false promises, of any number of trade practices, which must inevitably entail a penalty in terms of public irritation and loss of good will.

Two Extremes in Thinking

The past failures of television are deeply disturbing, even more disturbing in the light of certain recent statements advocating two utterly incompatible policies.

One group,—by far the more widely publicized,—proposes a headlong and intensive post-war expansion of television under existent standards; the other foreshadows a long period of practical stagnation, during which engineers would digest, adapt, and refine every element in the fabulous accumulation of electronic knowledge which the war has stimulated. The duration of this listless interval is estimated at approximately ten years, after which television would face the prospect of starting all over again. A ten-year cessation of operations is not directly advocated, but virtual cessation would be well-nigh inevitable. Neither proposal is feasible, or realistic.

The advocates of a hasty start for post-war television under present standards have chosen to place the emphasis upon "post-war", as though that phrase were, in some mysterious way, an open-sesame to the ultimate bonanza, a jackpot era of breathless expansion, of limitless public riches and unparalleled public demand. Whatever people are given, presumably the people will buy. Put a carburetor in a camel, and sell it for a sedan. But the cold fact is that, if present standards were not good enough to sell television in the last six months of 1941, they will not be good enough to sell television in the first six months following the war. To



TALLEST U. S. B

Rising 927 feet above the ground, a new radiator at WNAX is 0.53 wavelength long at the station's 570-kc frequency. Tieing-in of two smaller towers gives a directional night pattern

WNAX now has in operation the tallest tower used as a broadcast station radiator in the Americas. It is 927 feet overall above ground and 912 feet above the base insulator.

A construction permit was issued by the FCC and all required equipment was ordered long before the beginning of the war. The several towers required for the new antenna system were not, however, received until early 1943 and were placed in operation in September of this year.

Mounting Details

The single insulator on which the tower rests is 30 inches in diameter and 36 inches high. It was proof-tested to a compression load of 281 tons and sets in the center of a 4½ by 6 ft. concrete pier. The pier extends 9½ feet below ground and 12 feet above it. The foundation for the pier consists of a layer of concrete 2 feet thick and 16½ feet square. It was designed for a load-bearing soil capacity of 3,000 lb per square foot. Actual load-bearing tests after the excavation had been completed proved that the gravel bed on which the foundation was to be placed would easily withstand this load.

The first 24-foot section of the tower tapers out from the base insulator to a width of 15 feet. The remainder of the three-cornered tower structure maintains this width.

Six guy lines hold the tower erect. Three 1¼-inch lines are attached 377 feet above the ground and three 1½-inch lines are attached 735 feet above the ground. Both sets of guys are connected to three anchors, approximately 550 feet from the base of the tower. Each guy anchor contains 100 tons of reinforced concrete.

The lower guy lines and guy insulators were designed for a maximum tension of 57,800 lb. and the upper guy lines and insulators were designed for a maximum tension of 76,200 lb. Total normal weight on the base insulator (dead weight plus pull of guy lines) is 381,000 lb.

Tower lighting consists of 100-watt obstruction lights at the ¼ and ¾ heights, on each corner, and 1000-watt beacons at the center of the tower and at the top. Due to the difficulty of obtaining wire it was necessary to flash all tower lights.

Operation Modes

The 927-foot tower is used as the main tower during daytime operation and as part of a three-element directional antenna system at night. Two smaller towers with which it is associated consist of a 320-foot self-supporting type and a 449-foot self-supporting type. The 449-foot tower has been in use for some eight years.

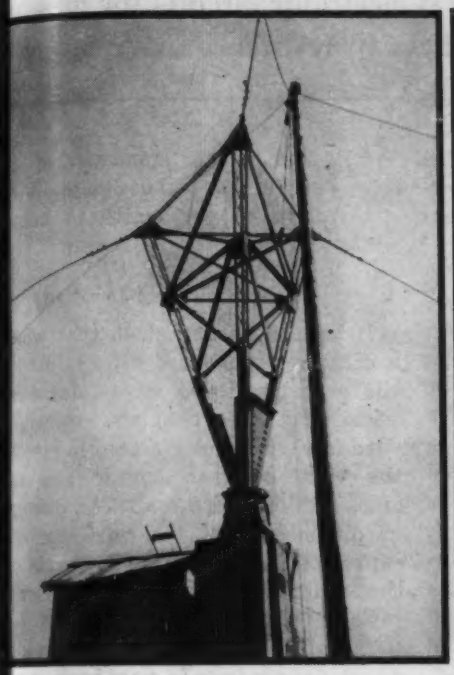
The 927-foot tower is located 900 feet from the transmitter building. With respect to the main tower, the 320-foot tower is spaced 526 feet and bears 25 deg. true. The 449-foot tower is also spaced 526 feet from the main tower and bears 155 deg. true.

The power-dividing network and phase-control networks are located in a phasing unit within the transmitter building. Two ⅜-in. gas-filled concentric transmission lines, buried five feet deep, run to each tower. They handle transmitted power and also carry sampling current back to the phase monitor and remote antenna meters in the transmitter building. A "T" network is used in the coupling unit at each tower.

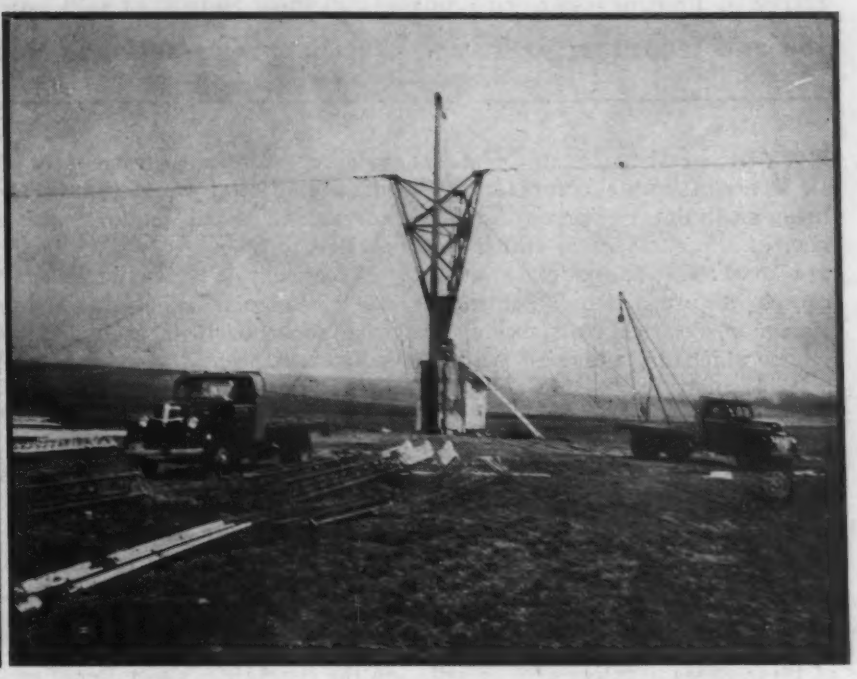
R-F contactors are used in each of the coupling units and in the phasing unit for switching from directional to non-directional operation. All contactors are operated from a push-button in the phasing unit.

BROADCAST TOWER

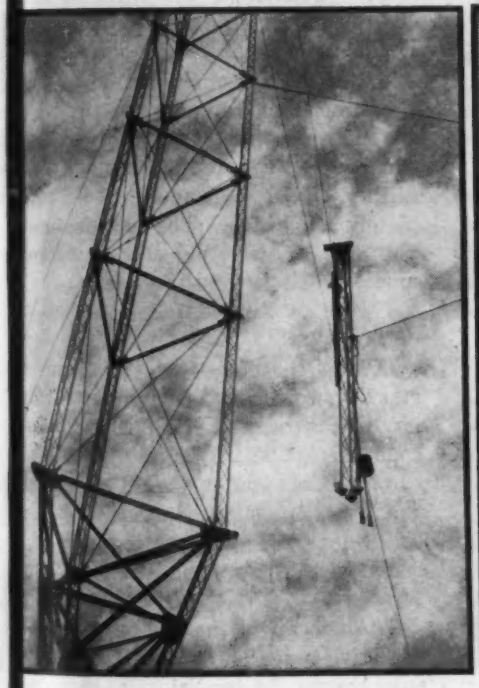
By CLIF TODD *Chief Engineer, WNAX, Yankton, S. D.*



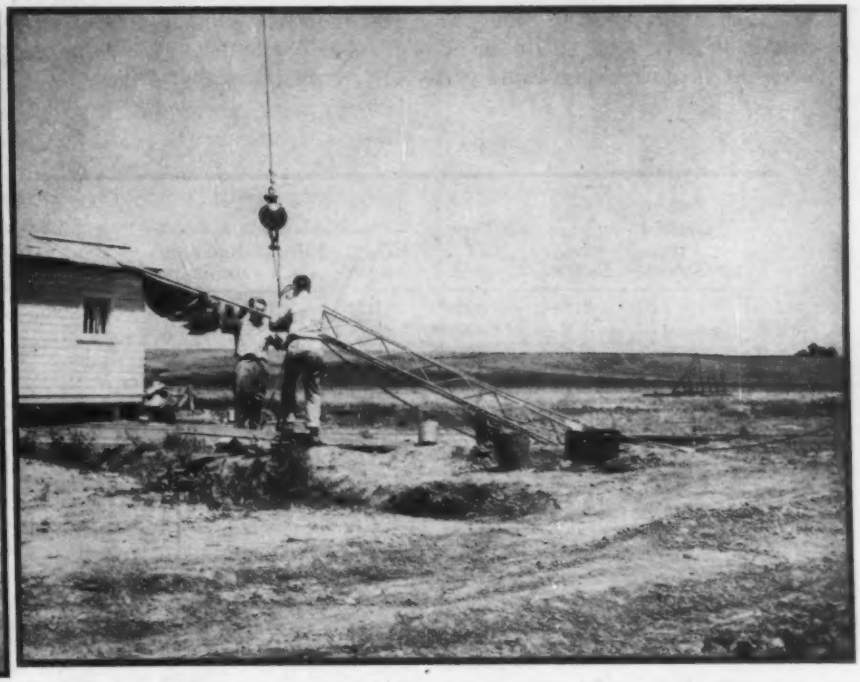
The base section is set in place



First section goes into position



Material on its way skyward



Hoisting the last section

STRAIN GAGES

A resumé of characteristics of wire resistance strain gages developed recently for determining stresses in structures and machines, such as in aircraft structural members, moving parts of locomotives, gun barrels during firing, etc. Typical electronic circuits for measuring and recording with high precision the fractional changes in resistance are also given

WIRE resistance strain gages are primary elements for measuring small linear changes of dimension of the surfaces to which they are attached. The surface strain causes a proportional percentage change of electrical resistance of the gage, which is measured with a suitable instrument. Most applications of these gages depend on the use of electronic instruments to get the necessary high sensitivity and measuring speed.

This type of gage was commercially developed about five years ago, largely because of pressure from the airplane industry for use in stress analysis applications. The number of these gages used per year is estimated to be over 500,000, most of which are for stress analysis. The use of these gages in industrial applications as conversion units in primary elements measuring some other variable in terms of strain or displacement is now being rapidly developed. The measurement of mechanical forces, weight, fluid pressures, and small motions are examples.

Practically all commercial gages are rectangular grids of resistance wire about 0.001 inch in diameter, supported and held in place by a film of elastic cement. This may be strengthened by the further use of a paper backing. This structure of wire and cement is in turn cemented to the surface on which strain is to be measured, as shown in Fig. 1. Electrical connections to the strain-sensitive wires are made through a pair of heavier lead wires, which are anchored securely so that pulls on the connection wires do not reach the strain sensitive grid.

The action of resistance strain gages depends largely on two factors, both of which have been tested experimentally many times:

(1) The effect of strain on the resistance of wires.

TABLE NO. 1

Type	Approx. initial res. (ohms)	Approx. sens. factor	Type of grid	Winding		Bonding cement	Wire
				Effect. length	Effect. width		
A1	120	2.0	6 strands	13/16"	1/16"	Cellulose	Constantan type alloy for static strain measurements
A5	120	2.0	10 strands	1/2"	1/4"		
A7	120	1.9	20 strands	1/4"	1/32"		
A8	120	1.8	40 strands	1/8"	1/16"		
A9	300	2.1	Double strand	6"	1/32"		
AB-1	350	2.0	16 strands	1 1/16"	1/16"	Resin	
AB-5	75	2.0	6 strands	1/2"	1/32"		
C1	500	3.5	8 strands	1 1/16"	1/32"	Cellulose	Isoelastic wire for dynamic strain measurements
C5	350	3.5	10 strands	1/2"	1/4"		
C7	500	3.3	30 strands	1/4"	1/8"		
C10	1000	3.3	50 strands	1/16"	1/4"		
CB-1	1000	3.5	16 strands	1 1/16"	1/16"	Resin	
CB-5	200	3.5	6 strands	1/2"	1/32"		
CB-7	500	3.3	30 strands	1/4"	1/8"		

(2) The exact transmission of strain to the gage wire through an elastic bonding cement.

(1) Resistance-Strain Sensitivity

It has long been known that when a conductor is placed either in tensile or compressive stress, its electrical resistance changes. When a wire is placed under a tensile stress the wire becomes longer and its cross-section decreases. The change in dimensions of the wire can be expressed rather simply in terms of the unit elongation and Poisson's ratio. However, the values of resistance change predicted from dimensional changes do not check at all closely with the changes experimentally measured.

For most metals, the strain sensitivity (defined as the ratio of unit change of resistance to unit strain) would be expected to be between 1.3 and 1.8 from a consideration of only the dimensional changes of the wire. Instead, most metals and alloys have sensitivity factors considerably higher. This has never been completely explained. The reason probably lies in an actual change of volume resistivity of the metal.

(2) Elastic Bonding Method

One of the phases of the commercial development of resistance strain gages has been the perfecting of a construction which would provide for easy attachment of the gage and exact transmission of surface strain to the sensitive wires with a constant sensitivity factor and without hysteresis.

The answer is the use of very fine sensitive wire supported along its full length by an elastic bonding cement. By using fine wire the ratio

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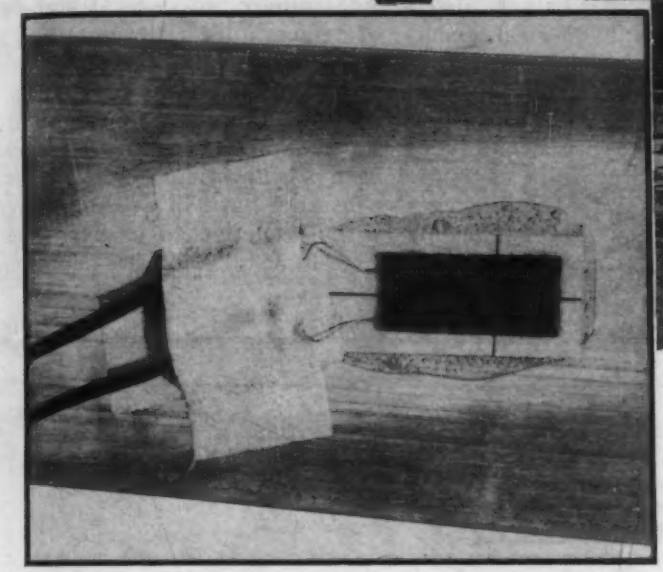

Wire resistance strain gage cemented to a girder flange

of the surface (or bonding) area of the wire to its cross-section area (or strength) is made high. Thus the axial strength of the wire is made small compared to the adhesive forces, which transmit the strain between it and the cement and between the cement and the surface to which it is attached. Also, the layer of cement between the wires and the surface is kept thin (about 0.0015 inch to the center of the wires) so that no shear or slippage can develop in the cement and cause errors.

The continuous support of the wire along its full length by the bonding cement has several other important results. First, the sensitivity factor is the same for both tension and compression. That is, when the gage is placed in compression, the wire has no chance to buckle because of the support of the cement. Second, the adhesion of the cement to the wire is so great that there is little opportunity for the wire to neck down at any weak point and so cause a local failure. As a result of this action, the gages can be worked at high strains with return of resistance to the original zero. Even when the "elastic" limit is exceeded, and the gage zero strain resistance does change, the strain sensitivity does not change.

Operating Characteristics

A knowledge of the mechanical and electrical operating characteristics of wire resistance gages is necessary to the designing engineer. The main operating characteristics are: (1) Maximum permissible strain range; (2) Gage sensitivity factor; (3) Permissible excitation; (4) Variation in initial gage resistance; (5) Temperature-resistance coefficient; (6) Permissible leakage resistance; (7) Frequency limitations; (8) Gage size. The first six of these

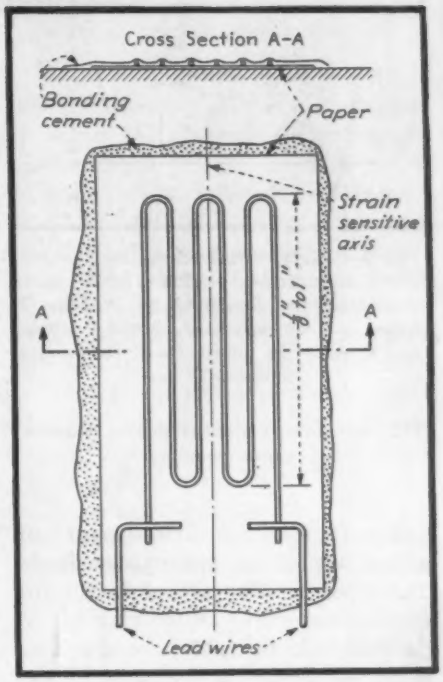

FIG. 1—Plan and cross-section views showing construction of a typical wire resistance strain gage

operating characteristics will now be taken up in turn and considered in relation to Table No. 1, which gives important electrical and mechanical characteristics for a selection of the commercial gages now on the market.

(1) Maximum permissible strain

range. The gages listed in Table No. 1 can be operated at elongations up to 1 percent with negligible drift or change in either sensitivity factor or zero strain resistance.

If return of the gage resistance to the original zero strain value after the removal of stress is not important, however, these strain gages can be operated beyond the elastic limit up to elongations of 2 to 3 percent. Under these conditions, gage resistance will not return to the same zero as before, but the strain sensitivity factor will remain constant.

(2) Gage sensitivity factor. This is defined as the ratio of unit change in resistance to unit strain causing this change. This is expressed mathematically as

$$\frac{\Delta R/R}{\Delta L/L} \qquad (1)$$

where ΔR is the change in gage resistance produced by strain, R is the gage resistance before strain is applied, ΔL is change in the length of the specimen, and L is the original length over which change is measured.

sensitivity factor of the gage. By the use of long, narrow loops, the gage is made comparatively insensitive to strains across the loops. It can be calibrated for strain sensitivity either along or across the loops.

(3) Maximum permissible excitation. Operation of strain gages with a maximum permissible excitation is obviously desirable because of the greater output voltage produced. Maximum excitation is determined almost entirely by the allowable heat dissipation in the gage. If the heat dissipated in the gage is enough to raise its temperature above that of the material to which it is attached, serious errors will be introduced. This is determined largely by the thermal conductivity of this material.

In general, it has been found satisfactory to operate 120-ohm gages attached to metal with a continuous excitation of three volts on static strain measurements. Where gages are being used for a short time only or where the only measurement be-

The variation in initial resistance may thus be several times as great as the total range of resistance change caused by strain. For this reason, it is necessary to provide an adjustment in instruments built for general use with strain gages to bring the initial reading at zero strain to the instrument scale zero, regardless of these variations in strain gage resistance.

(5) Temperature-resistance coefficient. This coefficient is determined primarily by the temperature-resistance characteristics of the sensitive wire and by the coefficient of thermal expansion of the material to which the gage is attached. Accordingly, no general statement of temperature characteristics for gages is possible.

Several methods of compensation for temperature errors can be used. The simplest and most generally used is connection of a dummy compensating gage in a bridge circuit with the active gage. The dummy gage is installed on a sample piece

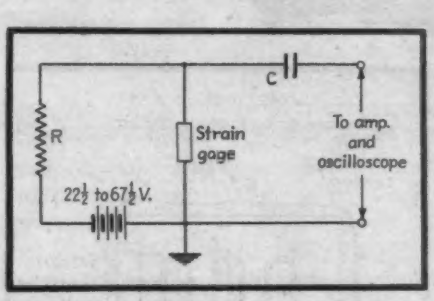

FIG. 2—Voltage divider circuit for dynamic strain measurement. Noninductive wire-wound resistor R should be at least 3 times the gage resistance. Battery voltage and R should be adjusted so gage current is about 30 ma

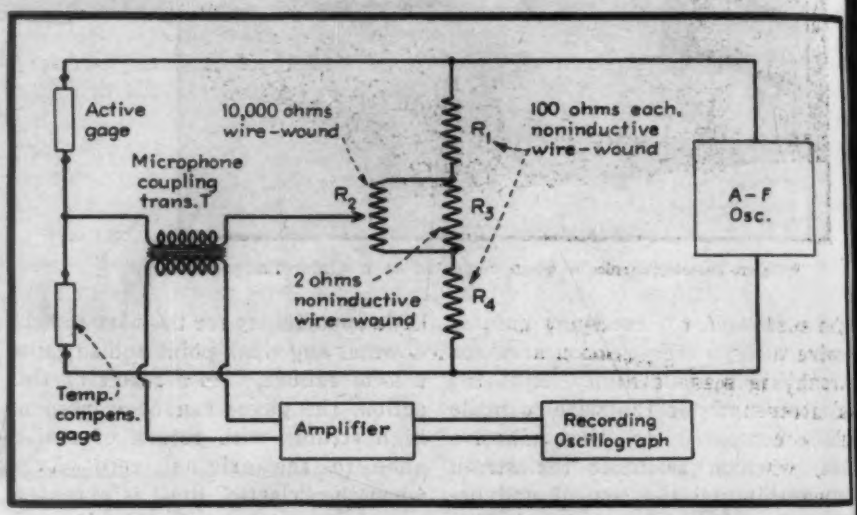

FIG. 3—Carrier current circuit for dynamic strain recording

The factors for various types of gages are given approximately in Table No. 1. The actual factor for commercial gages is determined experimentally to ±0.5 percent. This factor depends on the wire as described previously, the shape of the winding, and other variables in the manufacturing techniques. The fine wire used is sensitive to axial strains, but highly insensitive to lateral strains, hence the wire in the sensitive grid measures the average along the entire length of the wire. For this reason, the number and shape of the loops affect the

ing taken is that of strain variations, considerably higher gage excitation voltages can be used, but in no case should excitation be increased to over 10 volts on a 120-ohm gage.

(4) Variation in initial gage resistance. During manufacture, the resistance of type A-1 strain gages is held to ±0.25 percent of nominal value and to comparable accuracy for other types. However, differences in methods of installing may produce further variations in resistance which will be at least as great as the manufacturing tolerances.

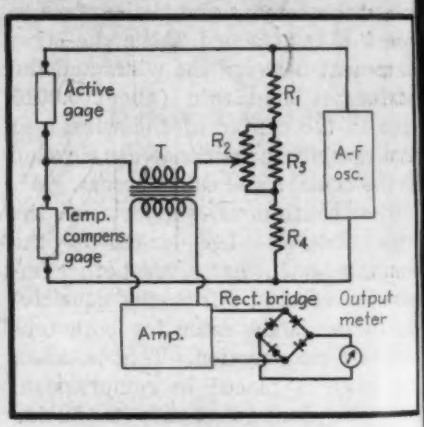

FIG. 4—Carrier current circuit modified to indicate instantaneous values of slowly varying strains

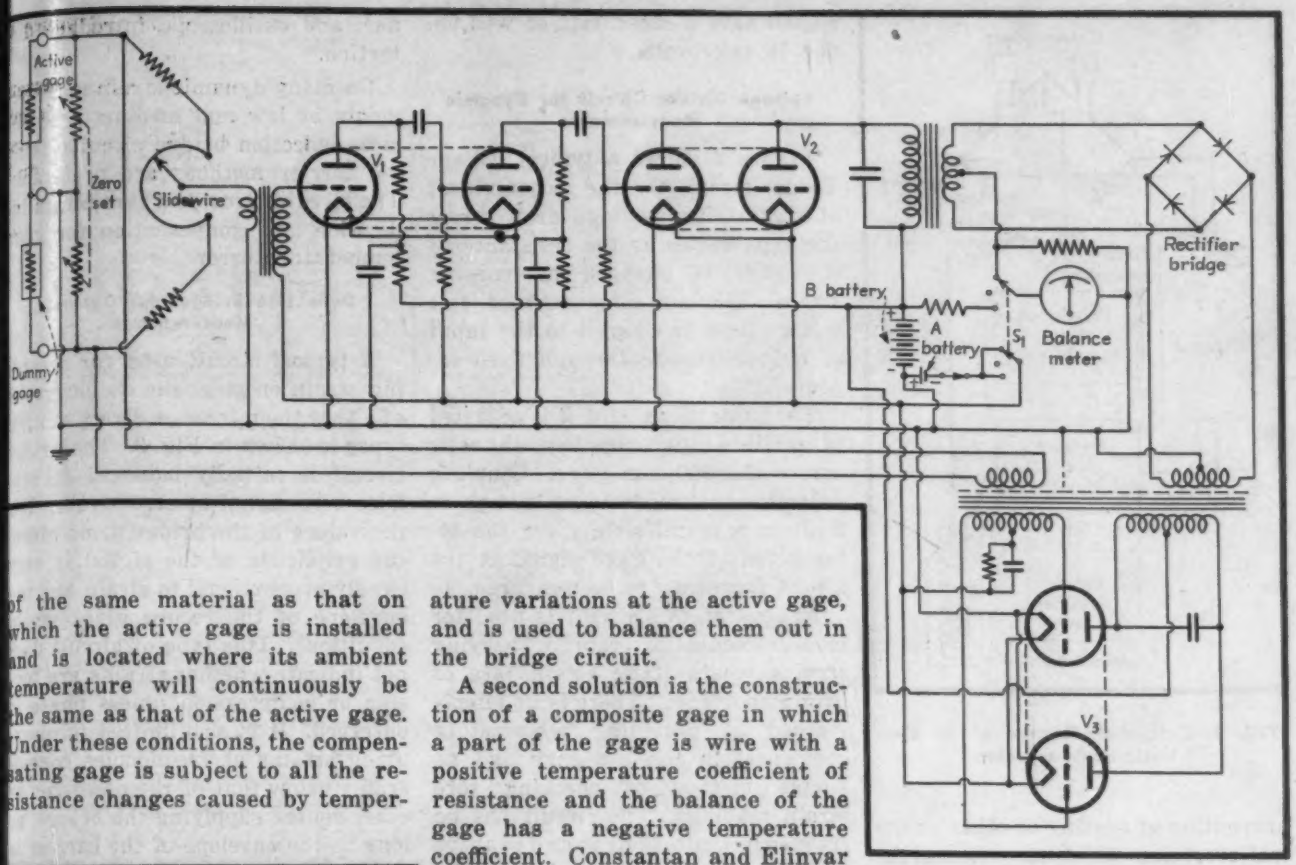

FIG. 5—Circuit of a portable commercial instrument for measuring static strain

of the same material as that on which the active gage is installed and is located where its ambient temperature will continuously be the same as that of the active gage. Under these conditions, the compensating gage is subject to all the resistance changes caused by temperature variations at the active gage, and is used to balance them out in the bridge circuit.

A second solution is the construction of a composite gage in which a part of the gage is wire with a positive temperature coefficient of resistance and the balance of the gage has a negative temperature coefficient. Constantan and Elinvar alloys are commonly used for the positive temperature coefficient section and Copel for the negative temperature coefficient section. In general, these must be designed by trial and error for the particular application.

A third solution is the selection of an alloy which by itself will give a zero temperature coefficient when installed on a particular metal. This solution is not practical under the present critical production conditions in the wire industry.

(6) Permissible leakage resistance. Because the percentage change of resistance of the gage is small, it is necessary to keep leakage resistance between the gage and ground high to prevent errors caused by such shunt resistance in the circuit. Generally these leakage resistances should be not less than 50 megohms and preferably should be of the order of 200 megohms.

Gages can be classified into two groups according to whether they are for static or dynamic strain measurements. As typically used, the gages for dynamic strain measurements will produce about six times as great an output voltage for the same strain as the static gages, and the dynamic gages have a temperature-resistance coefficient of about 25 to 50 times that of the static gages.

A further classification of gages is according to whether they use cellulose or resin bonding cement. In general, the cellulose gages are used for temporary installation at room temperatures. Resin gages are used for permanent installation and can be operated continuously at temperatures up to 300 deg. F.

Commercial model of a portable strain indicator using a manually balanced Wheatstone bridge with an electronic null balance indicating system

Installation of Gages

In general, it is best to obtain instructions from the manufacturer for the installation of gages. The following additional points may deserve some special mention. The main problem in the permanent installation of gages is that of stability; that is, constant zero strain resistance and permanently high leakage resistance. The first of these is taken care of adequately by making sure that the operating temperature and gage elongation are kept within satisfactory limits. High leakage resistance is almost entirely a matter of satisfactory waterproofing. Another reason for waterproofing is the

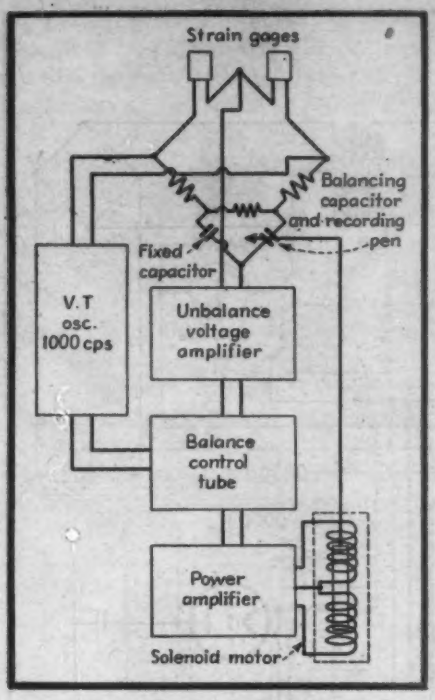

FIG. 6—Functional diagram of an electronic strain recorder

prevention of rusting or other chemical corrosion which may loosen the bond between gage and surface.

Electronic Circuits for Strain Gages

One of the design problems in working out suitable electronic instruments to measure strain with resistance gages is that of measuring with high precision a small fractional change in resistance of the gage which is caused by surface strain, where initial variations or temperature changes may cause variations in resistance several times as great. In terms of a typical example, the initial gage resistance would be 120 ohms with an initial variation of ±0.75 ohm, and a resistance change produced by strains of the order of ±0.25 ohm. For a ±0.25-percent measuring accuracy, resistance changes caused by strain would have to be measured to an accuracy of ±0.0006 ohm. Assuming a temperature-resistance coefficient for the wire of 10^{-6} per deg. C., the error caused by temperature changes might be of the order of 0.0012 ohm per deg. C. Compensation for ambient temperature errors would accordingly be necessary. Assuming gage excitation of 3 volts and a bridge circuit, the corresponding voltage change for full scale will be 0.00625 volt. For ±0.25-percent measuring accuracy, the balancing system should have a sensitivity of well under 16 microvolts.

Voltage Divider Circuit for Dynamic Measurements

Figure 2 shows a typical voltage divider circuit for the measurement of strain. The voltage drop across the gage varies as the resistance of the gage is changed by varying strain. The a-c component of this voltage drop is coupled to the input of an oscilloscope through fixed capacitor *C*.

The value of resistor *R* is adjusted to produce approximately 15 volts across the 500-ohm gage. Coupling capacitor *C* is made large enough to limit to a permissible value the attenuation of the gage signal at the lowest frequency to be measured.

In general, this circuit is used for measurements of rapidly varying strains where static strains are of little importance. There is no simple method of providing temperature compensation for the gage and no simple method of checking zero strain readings. The circuit has no frequency limitations from 0 to above 30,000 cps except as the characteristics of the coupling capacitor, amplifier, and oscilloscope introduce distortion.

On many dynamic strain measurements at low and medium frequencies, deflection bridge circuits using a-c carrier methods are preferable. The circuits provide a zero strain indication and compensation for gage temperature errors.

Deflection Bridges for Dynamic Measurements

A typical circuit used for recording strain on magnetic oscillographs of either the mirror or direct writing types is shown in Fig. 3. The bridge circuit is initially balanced to produce zero signal at zero strain. For the values of the bridge arms given, the amplitude of the signal is very closely proportional to strain and the envelope of the record gives strain conditions. This type of circuit does not indicate whether strains are tension or compression unless phase is observed. It is also limited to measuring strains at frequencies considerably below that of the oscillator or other source supplying the bridge, so long as the envelope of the carrier is used to read strain.

Figure 4 is essentially the same

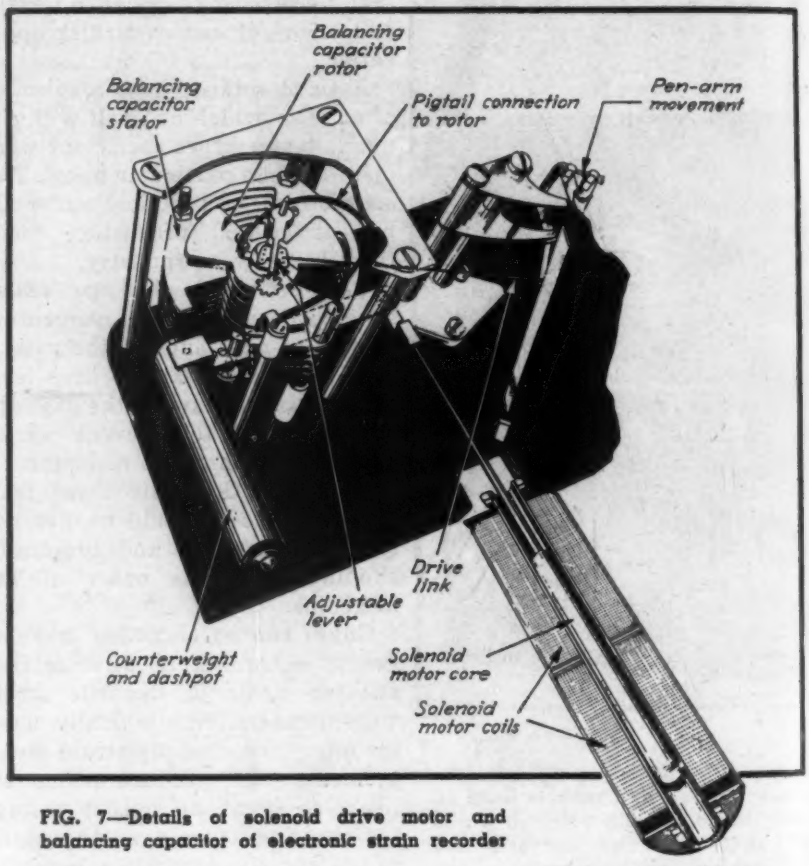

FIG. 7—Details of solenoid drive motor and balancing capacitor of electronic strain recorder

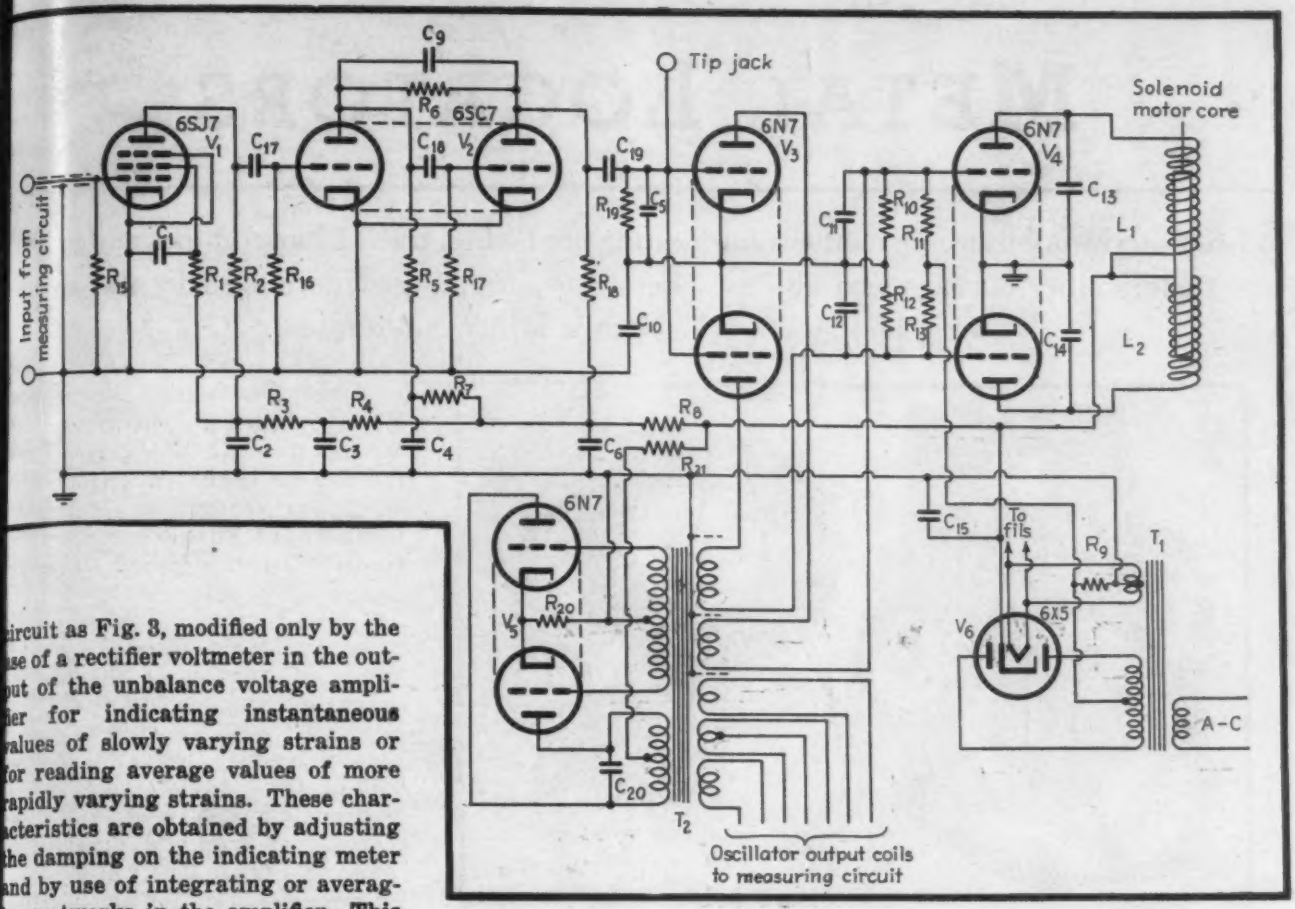

FIG. 8—Circuit diagram of balancing control unit for the electronic strain recorder

circuit as Fig. 3, modified only by the use of a rectifier voltmeter in the output of the unbalance voltage amplifier for indicating instantaneous values of slowly varying strains or for reading average values of more rapidly varying strains. These characteristics are obtained by adjusting the damping on the indicating meter and by use of integrating or averaging networks in the amplifier. This circuit does not indicate whether strains are tension or compression.

Manually Balanced Bridge for Static Strain Measurement

The complete circuit of a commercial instrument for the measurement of static strain is shown in Fig. 5. This instrument uses a manually balanced Wheatstone bridge with an electronic null indicating system. (Details of the operating adjustments for the measuring bridge have been omitted for clarity.)

The a-f oscillator supplying the excitation voltage to the measuring bridge circuit and the three-stage amplifier for the bridge unbalance voltage are entirely conventional. The output from the unbalance voltage amplifier and a phasing voltage from the oscillator are fed into the corners of the rectifier bridge. The null indicating meter is connected in a voltage-difference balance between the amplifier and the oscillator voltage sources. The action of this circuit produces through the meter a pulsating direct current that is proportional to the amplified unbalance voltage and has a polarity determined by whether the unbalance voltage is in phase or out of phase with the oscillator voltage. The balance meter thus indicates magnitude and direction of bridge unbalance.

Time-Strain Recorder for Static Strain

Figure 6 shows a block diagram of a self-balancing resistance bridge for continuous recording of strain on a single gage. In this instrument, adjustments are provided for making the instrument direct reading in micro-inches per inch of strain. These adjustments, which compensate for variations in initial gage resistance and also for different strain sensitivity factors, are omitted from the bridge wiring in the diagram.

A variable capacitor is used instead of a slidewire as the balancing arm of the bridge. The variable capacitor is designed for maximum capacitance variation with a rotation of about 45 deg. This small angular travel of the capacitor allows precise balancing action, as the capacitance variation is continuous as compared with the turn spacing limitation in spirally wound slidewires.

A resulting advantage of this construction is the use of a reciprocating solenoid-type motor instead of a rotating type with gear train. Figure 7 illustrates various details of this balancing capacitor and the solenoid drive motor. The advantages of using electronic units is striking in this instrument. Previous designs of instruments using galvanometers with motor-driven feeler and clutch mechanisms to reposition slidewire contacts had fifteen moving parts. In this strain recorder there are only five moving parts and these require no oiling or other periodic maintenance.

Circuit details for the electronic balancing control unit are given in the wiring diagram in Fig. 8. Tubes V_1 and V_2 are voltage amplifiers for the bridge unbalance voltage. These stages are conventional in design.

The amplified unbalance voltage is applied to both grids of dual-triode balance control tube V_3. The two plates of this tube are energized by equal but oppositely phased alternating voltages from the same oscillator which energizes the measuring bridge circuit. A pulsating direct cur-

(*Continued on page* 192)

METAL LOCATORS

A brief survey of electronic methods for locating ore bodies, tracing buried pipes and cables and finding other buried metal objects. Details of an amplifier developed by the author for geophysical work. Public utility applications.

FIG. 1—Geophone amplifier, pickup coil and headphones. Several locating systems use similar apparatus

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ELECTRONICS has found wide acceptance in another important field, that of geophysics, as well as in connection with such closely related problems as locating lost metal objects and tracing buried pipes and cables. All these applications deal with the behavior of energy transmitted through the atmosphere, earth or water, and especially with the deviation from normal behavior when this energy encounters a foreign body having an impedance or conductivity differing from that of the surrounding medium.

Any uniform energy-conducting medium may be thought of as normally having a definite or characteristic impedance to the transmission of energy. Energy traveling through this medium and encountering a sudden change in characteristic impedance will be reflected or will set up disturbing radiations which may be detected by locating instruments. When electrical energy passes through the earth, eddy currents and reflected waves are set up if a region of greater conductivity is encountered. The various electronic units to be described each depend on one or more of these principles.

The Geophone

The geophone, a device widely used in geophysical work, is essentially a rugged portable amplifier with a built-in vacuum-tube voltmeter. A geophone amplifier used by the author for experimental purposes is shown in Fig. 1. The coil picks up a-c magnetic fields for amplification by the geophone.

When the geophone is used for

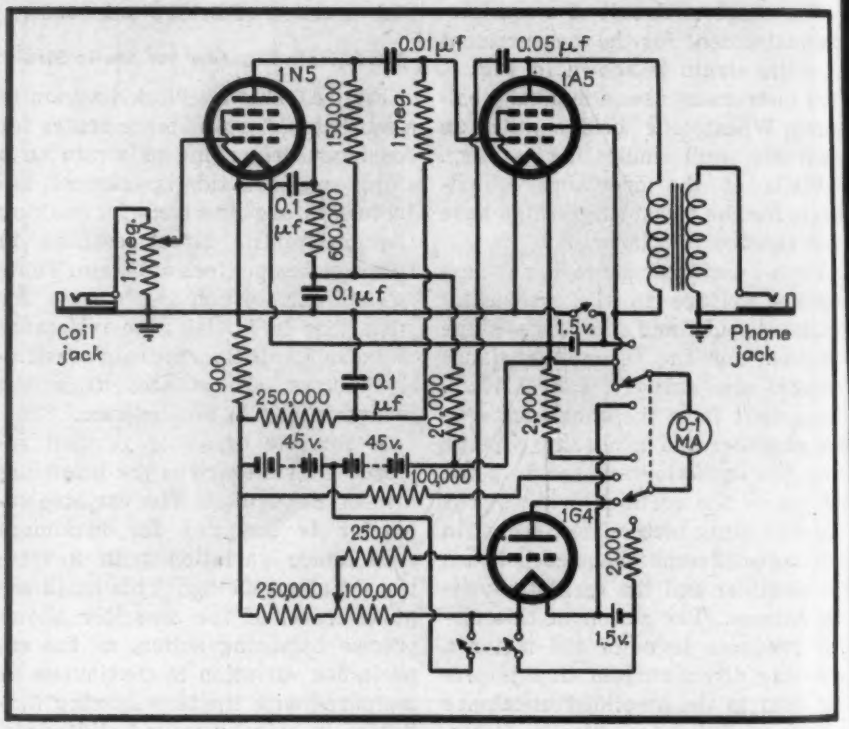
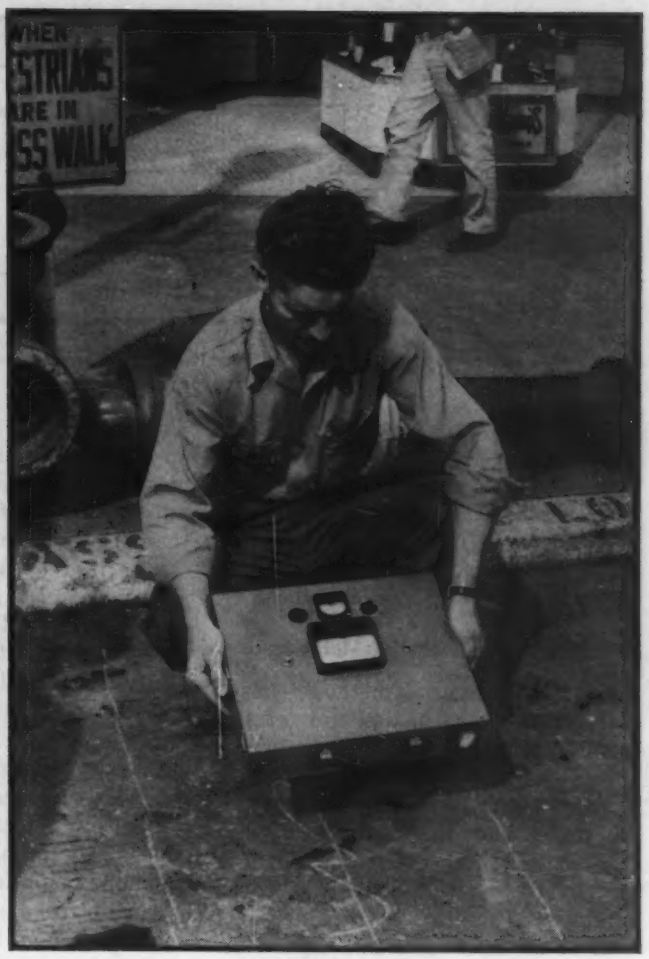


FIG. 2—Circuit diagram of geophone amplifier

Radio beat-frequency metal locator in use. This electronic device has been found particularly useful in public utility work



Using the receiver unit of a radio balance locator in tracing a pipe under the pavement. The transmitter is some distance away

tests requiring physical contacts to the earth, pointed steel contact rods are used for the connection. The headphones are usually used to indicate the signal, although the vacuum-tube voltmeter is useful for indicating maximum-signal adjustments as contrasted with the null points which are usually best detected by headphones.

The amplifier and vacuum-tube voltmeter circuits are shown in Fig. 2. The amplifier circuit is conventional except for the method of obtaining the bias for the 1A5. This bias is developed across the 900-ohm resistor in the negative B battery lead to both amplifier tubes.

A separate filament battery is necessary for the voltmeter tube since the filament is made more positive than $-B$ to obtain grid bias. This bias is adjusted by a potentiometer connected across the negative half of the B battery.

The voltage gain of this amplifier is 43 db. For most purposes this is enough, but another stage identical with the 1N5 voltage amplifier can be added if care is exercised in shielding the tubes and leads, and crystal headphones are used. The magnetic field from ordinary headphones would be fed into the pickup coil, with regeneration and oscillation as the probable result.

The Geophone Pickup Coil

The pickup coil design determines to a large extent the sensitivity and usefulness of the geophone. Usually, the desired result is maximum voltage from a very weak magnetic field, making it necessary to use a large number of turns (from 5,000 to 20,000 turns). The coil in Fig. 1 is wound in a ¾-inch wide x 1½-inch deep groove in a plywood ring 9 inches in outside diameter. It holds 5,000 turns of No. 36 enameled wire.

It is necessary to shield the coil from the effects of stray capacity and electrostatic charges. A practical form of shielding is copper, aluminum, or tin foil pressed around the ring and ending in a tape-insulated lap joint so as not to form a short-circuited turn. The foil is connected to the shield of the flexible coil lead. A small protractor level mounted on one side of the wood ring is very useful on some locating jobs.

Geophone Power Supply

For most applications the geophone amplifier system of location requires a source of a-c power or "transmitter" applied to the earth in the area being searched, or to pipes and cables when their course is being traced. For ordinary small locating jobs the conventional auto radio vibrator-inverter circuit arrangement shown in Fig. 3 furnishes ample power. For short periods of time, it may be used with dry cells; otherwise a six-volt storage battery is most economical.

When the geophone is used for searching large plots of ground for ore bodies, an engine-driven gener-

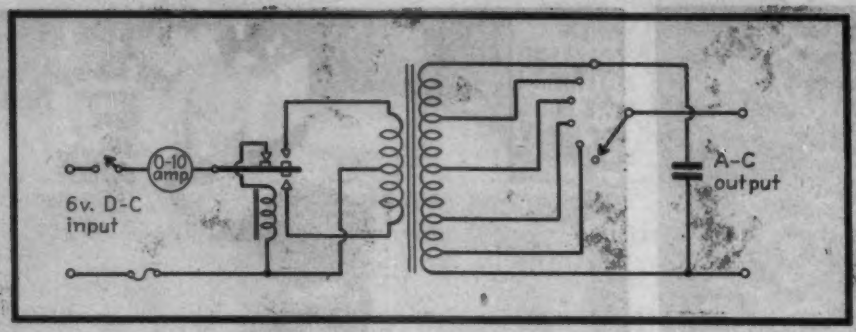


FIG. 3—Variable-voltage vibrator-inverter circuit used as a-c power source or "transmitter" for geophone amplifier

ator or power from a commercial line is desirable to create a stronger field. Tube oscillators have also been used, for generating audio-frequency power at higher frequencies than can be produced by mechanical vibrators.

The Equipotential Method

The equipotential method is used for locating ore bodies and tracing earth structures. It is also applicable for locating smaller metal bodies provided the measurements are proportioned according to the size of the lost body or object in question. A search for an ore body may cover many acres and the earth connections will be as much as a mile apart. In such cases the equipotential lines will be traced with separations between lines of as much as several hundred feet.

With this system one or more ground rods are driven on opposite sides of the area to be searched. If only one rod is used on each side they must be placed far enough apart so that the current distribution through the desired area is fairly uniform. The use of a greater number of ground rods aids in getting better current distribution. The source of power may be the vibrator supply previously described, for small areas. Large areas will require an a-c source with several hundred watts output.

The actual tests start at points previously measured off along the edge of the area, as in Fig. 4. The geophone amplifier with contact rods is used to feel along the equipotential lines. A man going ahead carries the amplifier and searches for the null point. After finding the null or equipotential point the operators advance and a rear man places his contact rod at the last equipotential contact point found by the leading man. A stake must be driven at each null test position so that the lines can be surveyed and plotted later.

Inspection of the plotted lines will reveal any marked changes in the earth conductivity. The equipotential lines run at right angles to the current lines. A buried conductor tends to concentrate the current so that the equipotential lines curve around the conducting body, and will curve away from a body having less conductivity than the surrounding earth. This is also shown in Fig. 4.

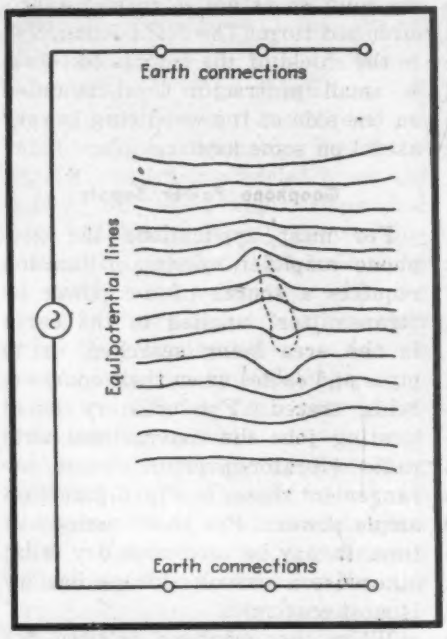


FIG. 4—Effect of a buried conducting mass on equipotential lines as measured with a geophone

The Sundberg Magnetic Method

The Sundberg magnetic method uses a large single-turn loop which encircles the area to be tested. The loop may be a rectangle as large as a mile long by a half mile wide. The loop should be larger than the area so that the magnetic field will be more nearly vertical in the area in question than it is near the loop conductor carrying the exciting current.

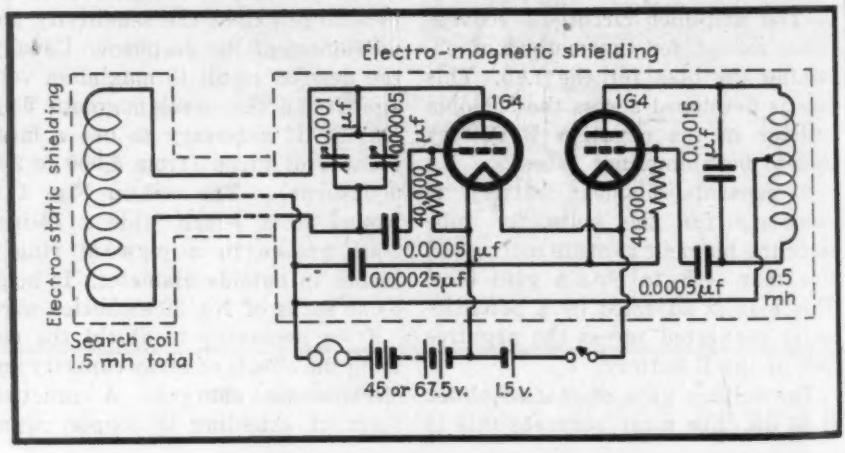
A conducting body in the field created within the loop will generate a secondary magnetic field from the eddy currents flowing in it. It is this secondary disturbing field which is detected and tells the story about the earth below. The geophone pickup coil is mounted on a tripod or on a surveyor's level so the angle of the magnetic field can be measured. The coil is adjusted to the null signal point and the angle recorded for each test location. Plotting these angles reveals the location of any buried conducting bodies.

As in the equipotential method, the source of power can be commercial power lines, an engine driven a-c generator, or the vibrator supply for small areas.

Prior to the actual testing a surveying crew marks off the area into squares. Stakes at the corners of the squares indicate the test locations.

When searching for small objects it is not necessary to mark off test locations. The coil can be hand-held in the null signal position. The operator can walk along, traversing the

FIG. 5—Circuit of radio beat-frequency metal locator developed by the author



rea in a systematic manner. When small conducting object is approached the signal will appear because of the rapid change of field angle resulting from the secondary magnetic field. Directly over the conducting object the field polarization will be normal, but all around it the pickup coil will have to be tipped from vertical toward the object to get a null adjustment.

Pipe and Cable Locating

A pipe and cable-locating method sometimes called the Darley System is useful for tracing the path of pipes, cables and other buried metal structures. It depends for its operation upon picking up the inductive field from a current flowing in the pipe or cable to be located. In the case of a power or communication cable normally carrying alternating current it is usually not necessary to apply an external signal. If other conductors carrying a-c power of the same frequency are close by, then a signal with a distinctive tone or frequency can be used to facilitate the tracing of the cable or pipe.

When a pipe line is being traced it is usually possible to make a connection to the pipe at some point where the location is known. When this is the case, the signal will be applied between the pipe and a ground rod or other ground connection. If a connection is not available then two ground rods somewhere near the pipe but spanning the unknown section, will feed sufficient current into the pipe.

Radio balance locator in use as a single carrying unit for geophysical prospecting

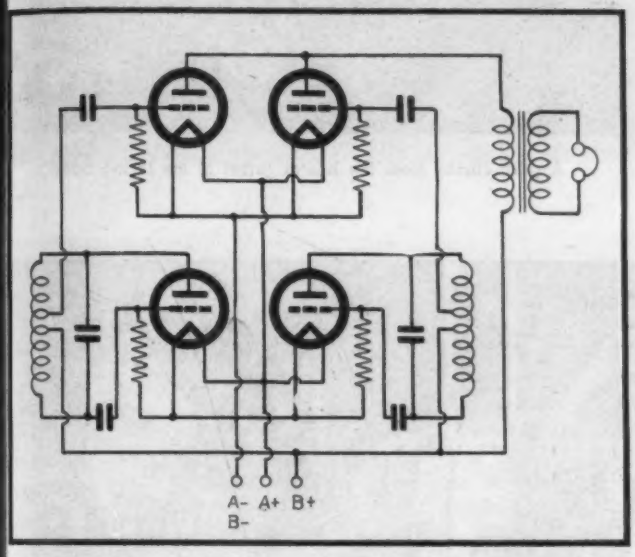


FIG. 6 — Using a buffer stage in this beat-frequency locator circuit minimizes the interlocking tendency between oscillators

The signal will be detectable for some distance on each side of the connection, depending on the soil resistance, depth, size and condition of the pipe. With a coated pipe, as is used for natural gas transmission across country, the signal is reasonably strong for a mile or more in each direction.

The geophone with pickup coil is used in this method also. The vibrator power supply is very satisfactory as a source of signal.

The null signal adjustment of the coil gives the most satisfactory indication of the position of the pipe or cable being located. The null signal exists when the axis of the coil is pointing at the center of the pipe carrying the tone signal. With the use of the level on the coil, the exact pipe location can be found. Also, the approximate depth of the pipe can be determined by backing away from the pipe until the null signal occurs at an angle of 45 deg. Then the depth of the pipe is equal to the distance from the point over the pipe to the 45-deg. position of the coil. The height of the coil above ground will be subtracted to get the true depth from the surface.

Under-Water Use

Pipes and cables under water can be traced very easily with the Darley method. If necessary, the coil can be made waterproof and lowered by means of the connecting wire. The signal will be detectable from the surface unless the depth is too great or other factors interfere.

The actual detecting is done by adjusting the position of the pickup coil until the null signal point is found. At this point the axis of the coil will project through the conductor carrying the tone signal. This is surprisingly accurate where there are no disturbing conductors.

Cable Fault Locating

Faults in communication and power cables can also be located by means of the geophone and the pickup coil. As in most locating, a certain amount of experience is necessary in order to interpret the signals resulting from the various faults in a cable.

(*Continued on page* 236)

NAVY RADIO in th

Officer aboard a seaplane tender, watching scout plane come in

A pilot climbs from the blister turret of his flying boat

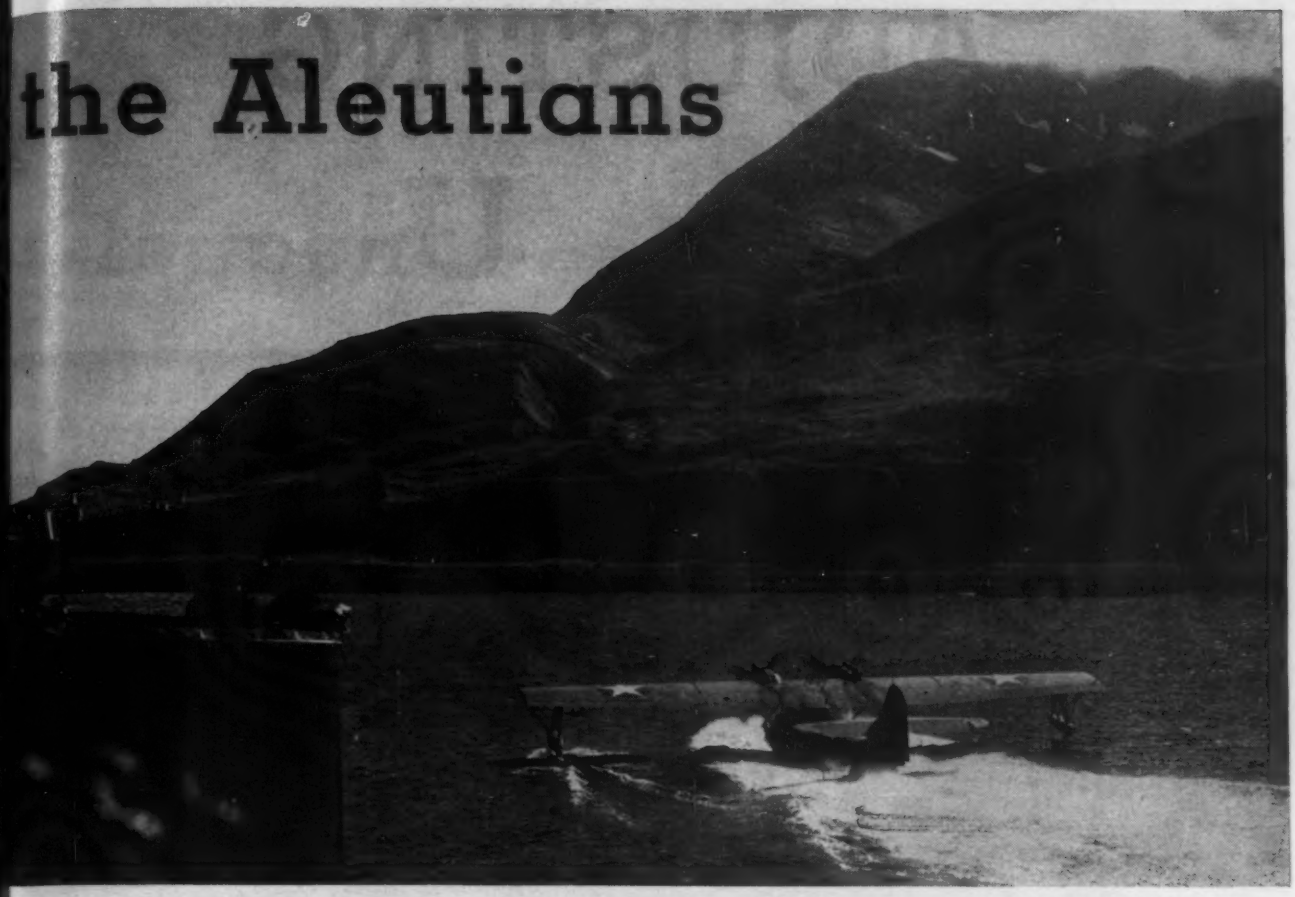
COMMUNICATIONS equipment plays a vital part in the efficient operation of ships serving as seaplane tenders. Photographs appearing here show some of the electronic gear aboard such a tender operating in the Aleutians and mothering a brood of long-range "Catalina" patrol-bombers, "Kingfisher" scout planes and PT boats.

Not all the gear is pictured here. The 2,000-ton ship boasts a switchboard for maintaining telephonic contact with nearby shore bases when at anchor, "bull-horns" and associated sound equipment which permits a "talker" to relay verbal orders all over the craft and for some distance across surrounding waters, and a maintenance room in which batteries powering radio equipment are charged and serviced.

Tenders constitute a complete "home base" for the smaller offensive and defensive units which they serve, effecting repairs, storing fuel, feeding and quartering crews.

Communications headquarters aboard the seaplane tender. Just one small corner of it is shown

the Aleutians



ABOVE

Home to its floating base comes a "Cat" seaplane. One of the ship's 40-mm guns is visible at the left. The rugged mountain range in the background towers up to 4,000 feet

LEFT

This plane, one of a squadron patrolling the bleak island chain, struck a hidden reef, was beached and is having her bilge pumped out

Official
U.S. Navy Photographs

ADJUSTING Unequal-

This two-tower directional array of station KDYL, with the main tower (behind the building) exactly twice the height of the other tower (at the right), is used as an example to illustrate the two methods developed by the authors for adjusting currents and phases to secure a desired nonsymmetrical radiation pattern

THE directional antenna array which has been in operation at radio station KDYL since the summer of 1941 is of somewhat unusual design, in that the two towers are of unequal height, with a large spacing between the towers. At the same time, the coupling and phasing networks were somewhat unorthodox. These factors, together with the rather diversified nature of the terrain, made an antenna problem of real interest to an antenna engineer. It is the purpose of this paper to relate the procedure followed in properly adjusting the array to obtain the required radiation pattern.

The Antenna Problem at KDYL

Prior to the installation of the array at KDYL, this station operated with a single nondirectional tower 400 feet in height, approximately one-half wave at the operating frequency. It was decided to use a second tower 200 feet in height to make up the directional array. By using this shorter tower, several thousand dollars were saved. The additional sky wave which would result by using a quarter-wave tower working in conjunction with a half-wave tower was desirable since the country surrounding Salt Lake City is mountainous, and the ground wave is highly attenuated.

It was felt, after three years of experience with the operation of the single half-wave tower, that it did not fit the requirements of broadcasting in Utah. High-angle radiation is vitally necessary in this part of the country, where the ground wave attenuates rapidly and the night sky wave provides a service to sections of the state which would have no service at all if dependent on ground wave transmission alone.

Figure 1 shows the desired horizontal polar diagram. The towers are located on a somewhat east-west line, with a tower spacing of 0.65 wave-lengths (233 electrical deg.) Tower No. 2 lies to the east of tower No. 1. If the two antennas were identical, desired shape of the horizontal pattern would be obtained if the current in tower No. 2 were 0.6 of that in No. 1, and if the current in No. 2 lagged the current in No. 1 by 45 deg. If the horizontal angle ϕ is measured counter-clockwise from the east line of towers as shown on Fig. 1, the shape of the horizontal field pattern is given by

$$F_\phi = \frac{1 + 0.6 \angle -45° + 233° \cos\phi}{1.6} \quad (1)$$

where

$$\bar{I}_2 = 0.6\,\bar{I}_1 \angle -45° \quad (2)$$

This horizontal radiation diagram is replotted in Cartesian coordinates in Fig. 2. This was done for greater ease of comparison with other similar patterns in the work about to be described. This type of pattern in Cartesian coordinates gives greater detail in the null points than when plotted in polar coordinates.

The relation shown in Eq. (2) is predicated on the assumption that

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Chief Engineer, Station KDYL, Salt Lake City, Utah

Tower Broadcast Arrays

When towers of unequal height are used in a broadcast directional array, adjustments are complicated by the fact that magnitudes and phases of base currents may differ from those of the radiated fields. Two methods are presented for minimizing cut-and-try adjustments, one involving simple field strength measurements and the other using model antennas

the towers are identical, so that the fields produced by each tower at a point in the horizontal plane lying on the perpendicular bisector of the line of towers have the same respective phase relations with the base currents of the towers and bear the same proportionality factor. When the towers are of unequal height, equal currents at the bases of the two antennas may produce greatly unequal fields. Furthermore, with the base currents in phase, the two fields produced at this point may be distinctly out of phase.

Analysis for Unequal Towers

An explanation of this effect may be found by referring to Fig. 3. This picture should be regarded as entirely qualitative, but illustrative of the phenomena in question. The current along an antenna may be regarded as made up of a main current wave traveling up the tower, retarding in phase as it travels and decreasing exponentially in value. A second

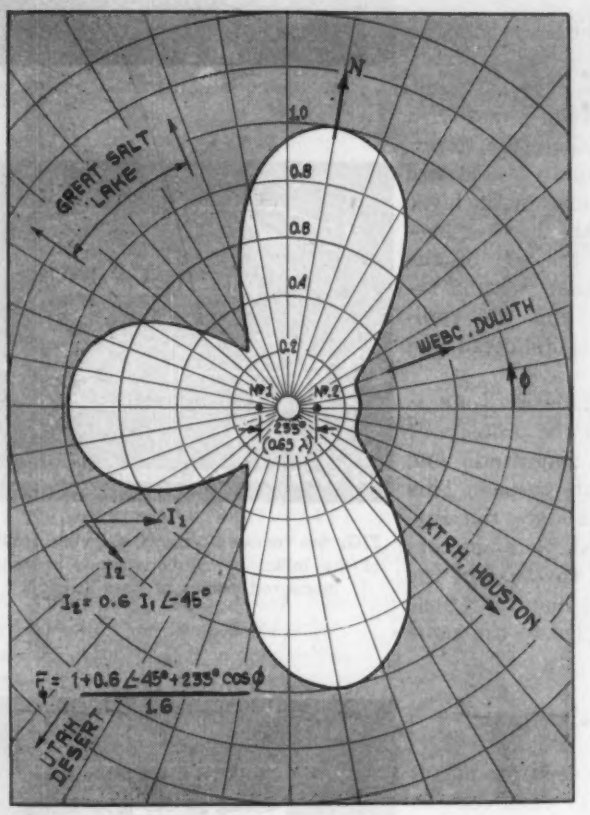


FIG. 1—Radiation pattern desired for KDYL in Salt Lake City, with nulls on two other 1320-kc stations and on two nearby sparsely populated areas, the Great Salt Lake and the Utah desert

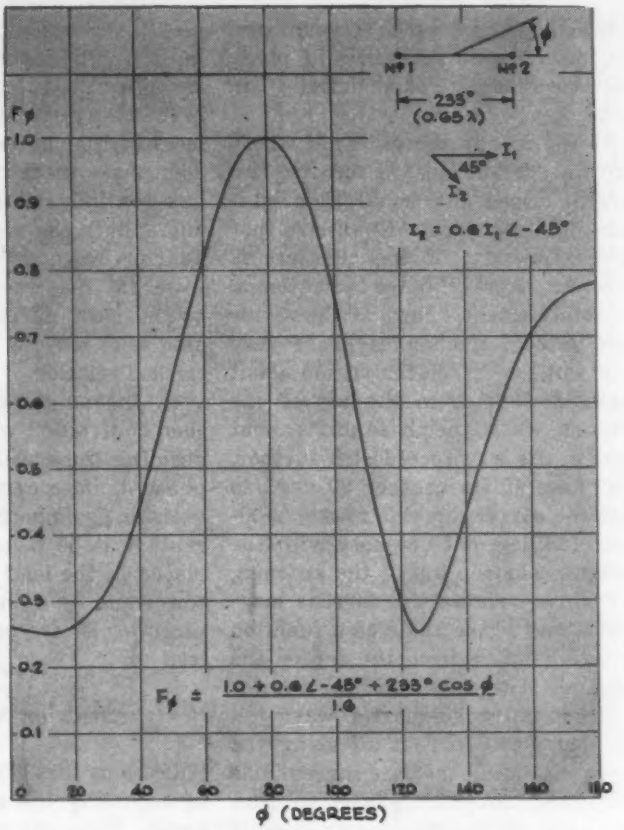


FIG. 2—Upper half of the radiation pattern of Fig. 1, replotted in Cartesian coordinates with degrees measured counterclockwise from the horizontal line extending to the right through the towers

correct the pattern could be made, ich soon degenerates into a good l of cut-and-try with the coupling d phasing networks. This first ocedure requires a great deal of ne, much trudging around the untryside with a field intensity eter, and the patience of Job[1].

As a second means of adjustment, e might consider placing the phase onitor pickup coil on the tall tower out half-way up the tower, so that e correct phase would be monitored. his does eliminate the uncertainty phase monitoring, but makes ecessary the use of an extra trap rcuit to bring signal from this coil the phase monitor across the base sulator. To assist in establishing se current phase relationships for e in designing phasing networks, is then necessary to place another ase monitor pickup coil at the base the tower and measure the phase tween the base current and the rrent at the middle of the antenna. his system was not used because of e mechanical difficulties of mount- g the upper coil on the tower as ell as the necessity of the trap cir- it already mentioned.

The third possible means is that llowed by the authors, in which the ecessary relations were established om field measurements and were erified by the use of model antennas.

Field Measurements

After the transmission lines to the wo towers were completed, arrange- ents were made so that a small mount of power could be fed to ther tower. Then a clear spot of round on the line of towers and bout three miles east of the array as selected and a field intensity eter located there. This is point A n Fig. 5. The distance to this point unimportant as long as the dis- nce from the array to point A is of he order of 20 times or more than he spacing between towers.

Since tower No. 2 is about one- uarter wave in height and therefore esonant if grounded, this tower was loated on its base insulator so that it would be distinctly out of tune. Then ower No. 1 was fed with a small mount of current. In this case, it was ossible to get 3.0 amp into this tower. With the current held at this value, he field intensity at point A was easured, and found to be 78.0 mv

[1] Job, i, 1-22; ii, 1-13.

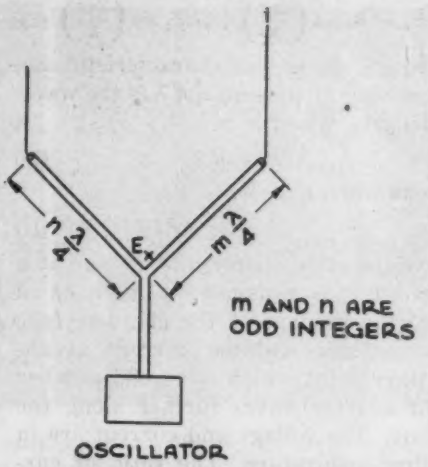


FIG. 8—Method of feeding model antennas

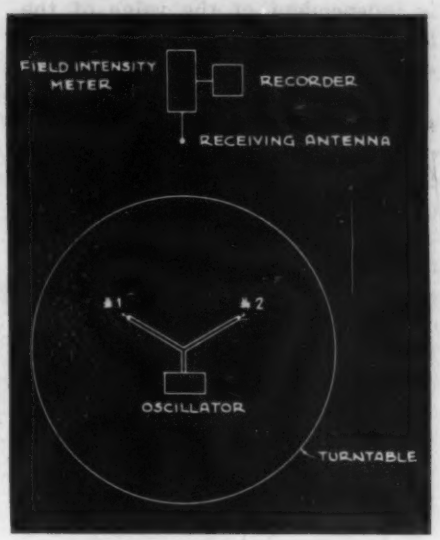


FIG. 9—Relationship of rotatable model antennas to measuring equipment

per meter. Thus, I_1 is 3.0 amp and $F'_{A,1}$ (field at A due to current in No. 1) is 78.0 mv per meter. Thus, I_{A1} is 3.0 amp and F_{A1} (field at A due to current in No. 1) is 78.0 mv per meter.

The field at A is directly proportional to the current in the antenna, so that

$$F_{A,1} = K_{A,1} I_1, \text{ or} \quad (3)$$

$$K_{A,1} = \frac{F_{A,1}}{I_1} = \frac{78.0}{3.0} = 26.0 \text{ mv per meter at point } A \text{ for 1 amp in No. 1} \quad (4)$$

No. 1 was then grounded to throw it out of action, and No. 2 was fed with 3.8 amp. The field at A was now found to be 65.0 mv per meter. Then I_2 is 3.8 amp, $F_{A,2}$ is 65.0 mv per meter, and

$$F_{A,2} = K_{A,2} I_2. \quad (5)$$

$$K_{A,2} = \frac{F_{A,2}}{I_2} = \frac{65.0}{3.8} = 17.1 \text{ mv per meter at point } A \text{ for 1 amp in No. 2} \quad (6)$$

To meet the desired conditions implied by Eq. (2),

$$F_{A,2} = 0.6\, F_{A,1} \quad (7)$$

Substituting Eq. (3) and (5) in (7), we obtain

$$K_{A,2} I_2 = 0.6\, K_{A,1} I_1, \text{ or} \quad (8)$$

$$I_2 = \frac{0.6\, K_{A,1}}{K_{A,2}} I_1 = 0.912\, I_1 \quad (9)$$

We have thus found that to obtain the desired field pattern of the directional array, Eq. (9) must be satisfied.

Similar measurements at point B, Fig. 5 yield

$$K_{B,1} = 24.0 \text{ mv per meter at point } B \text{ for 1 amp in No. 1} \quad (10)$$

$$K_{B,2} = 15.78 \text{ mv per meter at point } B \text{ for 1 amp in No. 2} \quad (11)$$

Point B is about the same distance from the array as point A, but need not be equal to it, and again the distance need not be measured. These values serve as a check on Eq. (9) and yield

$$I_2 = \frac{0.6\, K_{B,1}}{K_{B,2}} I_1 = 0.912\, I_1 \quad (12)$$

The next step in the procedure is that of determining the correct phase angle of the base currents. No. 2 tower was measured and found to have a resistance of 69.0 ohms and an inductive reactance of 147.0 ohms. A capacitor with a reactance of 147.0 ohms was placed from the bottom of the tower to ground, with an ammeter in the lead from the tower to the capacitor. Thus tower No. 2 was tuned to resonance.

Power was then fed to tower No. 1. With the current in No. 1 equal to 6.5 amp, it was found that the current in No. 2 was 2.6 amp. Then the phase relation between these two currents was measured with an RCA Type 300-A Phase Monitor*, and it was found that the current in No. 2 lagged the current in No. 1 by 159 deg. The fields at the measuring points were again measured. The following data has thus been accumulated:

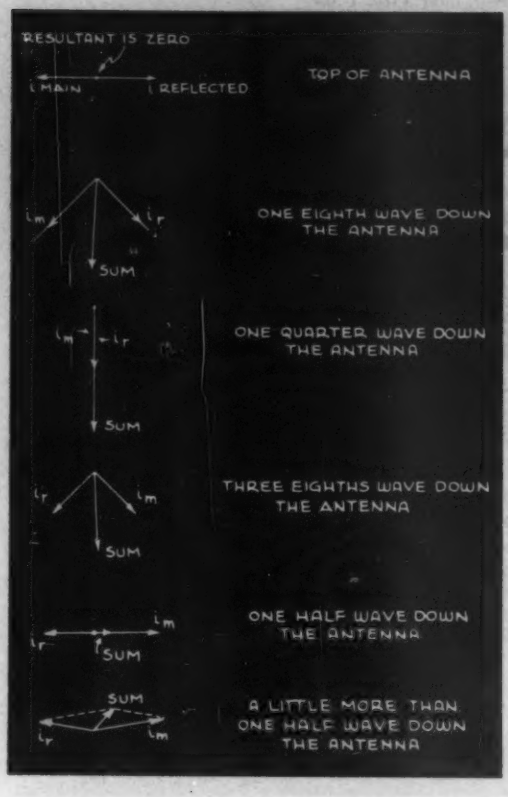
$I_1 = 6.5$ amp
$I_2 = 2.6$ amp
$F_A = 140$ mv per meter
$F_B = 144$ mv per meter
$kd = 233$ deg
$K_{A,1} = 26.0$ mv per meter per amp
$K_{A,2} = 17.1$ mv per meter per amp
$K_{B,1} = 24.0$ mv per meter per amp
$K_{B,2} = 15.78$ mv per meter per amp

When the above values are substituted in Eq. (7a) and (8a) in the Appendix, we find $\sin \Delta = -0.1935$, and $\cos \Delta = 0.965$, so Δ equals -11.5 degrees.

The results of these calculations are shown at (a) in Fig. 6. At the time that the current I_2 lagged I_1 by

* Brown, George H., and Swift, Gilbert, A Radio-Frequency Phase Meter with Many Uses, *Broadcast News*, p. 8, July, 1938.

FIG. 3 (BELOW)—Vector diagrams illustrating how the total current in a tower changes in phase at different points on the tower


RESULTANT IS ZERO
I MAIN
I REFLECTED
TOP OF ANTENNA
ONE EIGHTH WAVE DOWN THE ANTENNA
SUM
ONE QUARTER WAVE DOWN THE ANTENNA
THREE EIGHTHS WAVE DOWN THE ANTENNA
ONE HALF WAVE DOWN THE ANTENNA
A LITTLE MORE THAN ONE HALF WAVE DOWN THE ANTENNA

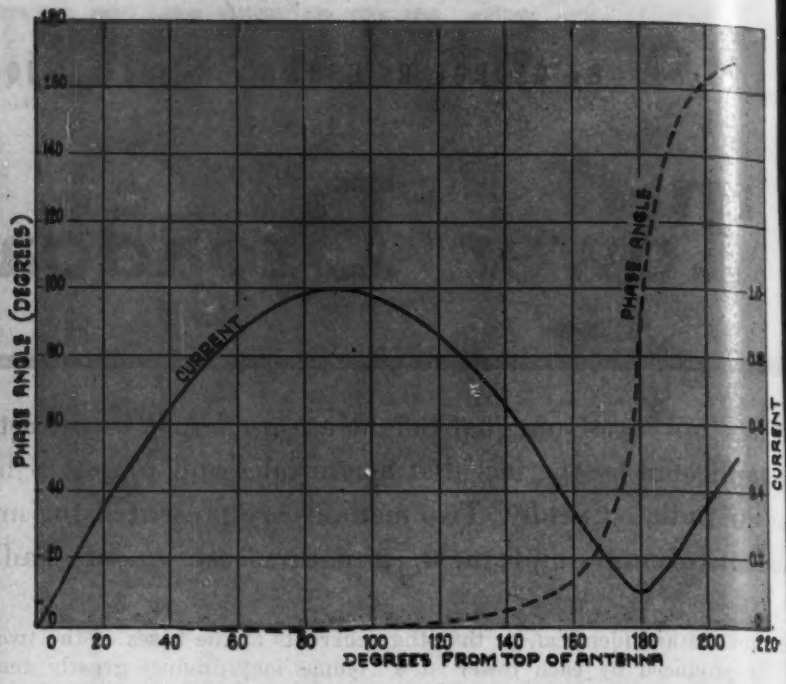
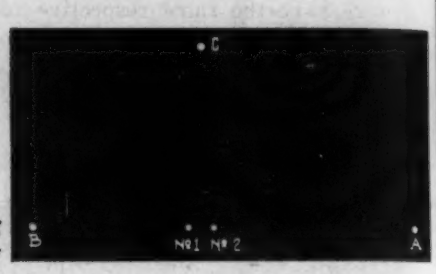


FIG. 4 (ABOVE)—Variation of magnitude and phase angle of total tower current with distance from the top of the tower

FIG. 5 (RIGHT) — Measuring points (*A*, *B* and *C*) used in the field measurement method, with each tower in turn being energized



reflected current wave travels down the tower, again retarding in phase and decreasing exponentially in value.

At the top of the antenna, where the total current must be zero, the two current waves are equal in magnitude and exactly out of phase so that the vector sum of the currents is zero. As we travel down the antenna, the total current, shown as the vector sum in Fig. 3, changes phase very little until we reach the region about one-half wave from the top of the antenna, where the phase shifts about 90 deg. As we proceed still further, the phase shifts another 90 deg., so that the current in this region is almost 180 deg. out of phase with the current near the top of the antenna.

Figure 4 shows the current magnitude and phase angle as a function of the distance from the top of the antenna. It is shown that for a tower which is only one-quarter wave tall (90 deg.) the current all along the tower, including the base current, has essentially constant phase, so that the radiated field bears a simple phase relation with the current at the base of the tower. However, if the tower is close to one-half wave in height (180 deg.), the current along most of the tower is substantially constant in phase, but the base current is very much out of phase with most of the current along the tower. The phase of the radiated field will be essentially determined by the large currents in the neighborhood of one-quarter wave from the top of the tower, so that the phase relation between base current and the radiated field may be a complicated and critical relation.

In the actual installation, one is then confronted with the problem of deciding just what magnitude and phase of base currents to use. This decision is important since the currents will be metered by ammeters placed in the lead at the base of the tower and by a phase monitor whose pickup coils are coupled to the same lead.

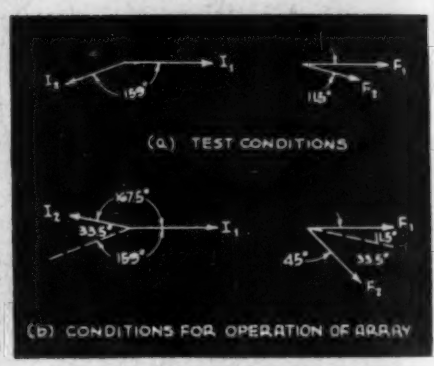


FIG. 6—Vector diagrams showing results of the initial calculations made with the measured values of field strength

Choice of Three Methods

It seems that three separate means of adjusting the array could be followed. First one might simply guess at the desired networks needed, set up the system and examine the field pattern obtained. Then adjustments

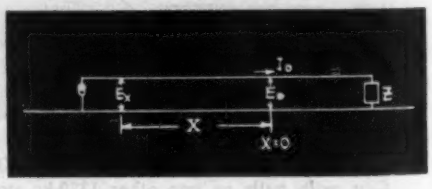


FIG. 7—Terminated transmission line upon which Eq. (16) and (17) are based

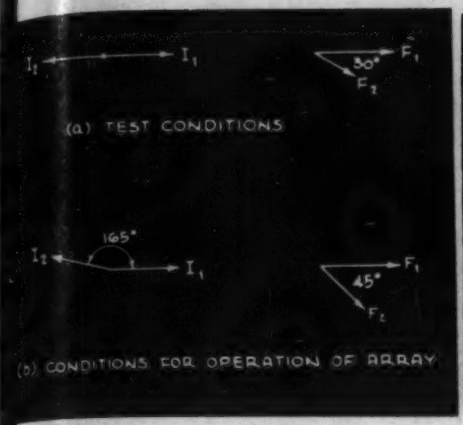


FIG. 12—Vector diagrams for model antenna method

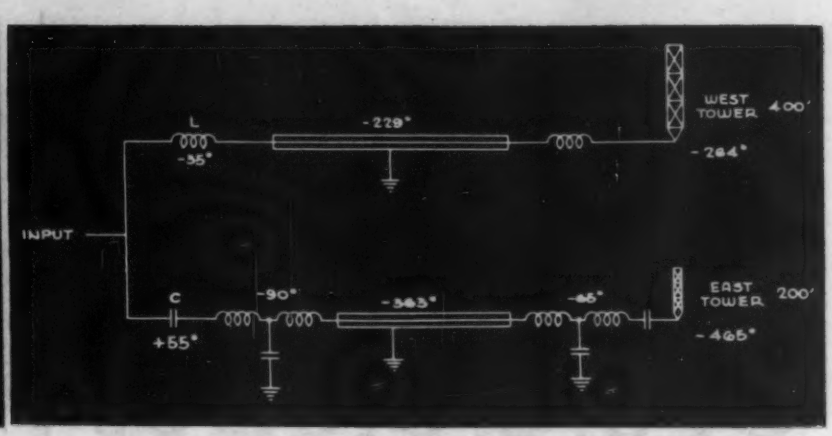


FIG. 13—Complete phasing and coupling finally used at KDYL

$$\frac{1 + 0.65 \angle -30° + 233° \cos \phi}{1.65}$$

This gives us the information that when $\bar{I}_2 = I_1 \angle -180°$, the effective radiating fields were $\bar{F}_2 = 0.65 F_1 \angle -30°$. These conditions are shown at (*a*) in Fig. 12. As was done earlier in the paper, we turn F_2 in a clockwise direction until the desired 45-deg. angle is obtained between the fields. For this condition, we find that I_2 leads I_1 by 165 deg.

Since we desire the field ratio to be 0.6, and we have found that equal currents yield a field ratio of 0.65, the necessary current ratio is 0.6/0.65 or 0.923.

Thus, for operation of the array, we find that the base current condition shall be

$$I_2 = 0.923 I_1 \angle +165° \qquad (18)$$

Phasing and Impedance-Matching Circuits

The data previously obtained was sufficient to yield the mutual impedance between the antennas. With tower No. 2 resonated and grounded, and with tower No. 1 fed directly,

$$-\bar{I}_1 \bar{Z}_m = \bar{I}_2 R_{2,2} \qquad (19)$$

Since $\bar{I}_1$ is 6.5 amp at zero deg. phase angle, $\bar{I}_2$ is 2.6 amp at −159 deg., and $R_{2,2}$ is the self resistance of tower No. 2 and is 69.0 ohms, we find that $\bar{Z}_m$, the mutual impedance between the antennas, is $27.6 \angle +21°$.

Our next step is to determine the impedance of each antenna when the array is fed with the desired current ratio and phase angle. We postulate that the currents will be related by the relation

$$\bar{I}_2 = 0.912 \bar{I}_1 \angle +167.5°$$

Then the impedance of tower No. 1 during operation of the array is

$$\bar{Z}_1 = \frac{\bar{V}_1}{\bar{I}_1} = R_{1,1} + jX_{1,1} + \frac{\bar{I}_2}{\bar{I}_1}\bar{Z}_m \qquad (20)$$

Here $R_{1,1}$, the self resistance of No. 1, is 96.5 ohms, and $X_{1,1}$, the self reactance of No. 1, is −165.0 ohms. When these values are inserted in Eq. (20) we find that

$$\bar{Z}_1 = 71.7 - j168.8 \text{ ohms} \qquad (21)$$

Also, $R_{2,2}$, the self resistance of No. 2, is 69.0 ohms, and $X_{2,2}$, the self reactance of No. 2, is + 147.0 ohms, so the impedance of tower No. 2 during operation of the array is

$$\bar{Z}_2 = \frac{\bar{V}_2}{\bar{I}_2} = R_{2,2} + jX_{2,2} + \frac{\bar{I}_1}{\bar{I}_2}\bar{Z}_m = 44.0 + j130.3 \text{ ohms} \qquad (22)$$

Since the array is fed with concentric transmission lines which have a characteristic impedance of 70 ohms, tower No. 1 was matched to its transmission line by the simple method of inserting a single inductance coil in series with the antenna to cancel out the capacitive reactance of 168.8 ohms. The effective resistance of No. 1 was so close to 70 ohms that a resistance-changing network was not considered necessary. A T network was placed at tower No. 2 to convert the impedance Z_2 to a pure resistance of 70 ohms. This network introduced a phase delay of 65 deg. The complete phasing and coupling system is shown in Fig. 13. The 90-deg. lagging network at the input of the transmission line leading to tower No. 2 was used simply for phase shift, with no impedance conversion.

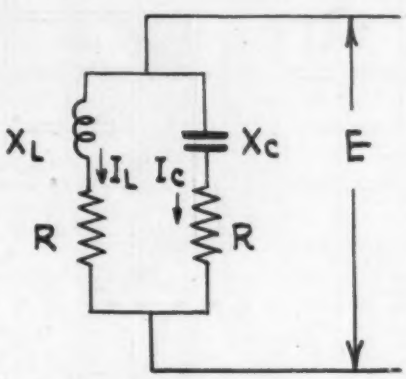


FIG. 14—Simple power-dividing network

The inductance L and capacitance C in this diagram form an interesting yet simple power-dividing network. Its operation may best be described by referring to the circuit of Fig. 14. The two resistors R in this case each represent the 70-ohm loads furnished by the transmission lines and their associated networks. The reactance of the capacitor may be selected at random. We will designate the relative value with respect to R as M, so that

$$X_C = MR \qquad (23)$$

Our remaining condition is that when once the capacitance has been set at a selected value, the inductance will be set to have the value

$$X_L = R/M \qquad (24)$$

Then

$$\bar{I}_L = \frac{\bar{E}}{R + jX_L} = \frac{\bar{E}}{R + jR/M} = \frac{M\bar{E}}{MR + jR} \qquad (25)$$

$$\bar{I}_C = \frac{\bar{E}}{R - jX_C} = \frac{\bar{E}}{R - jMR} = \frac{j\bar{E}}{MR + jR} \qquad (26)$$

Dividing Eq. (25) by Eq. (26),

$$\bar{I}_L/\bar{I}_C = -jM \qquad (27)$$

Thus we see that the current in the inductive arm always lags the current in the capacitive arm by 90 deg., and is M times in magnitude. This allows us to vary the power division between towers without changing the phase of the currents.

Another useful property of this

(*Continued on page* 288)

159 deg., the field F_2 lagged the field F_1 by 11.5 deg. The results of turning F_2 clockwise until it lags F_1 by 45 deg. are shown at (b) in Fig. 6. This turning of F_2 is accompanied by a turning of I_1 through the same angle, so that we see that I_2 actually leads I_1 by 167.5 deg. when the fields are in the phase relation which will yield the desired field pattern. Thus, from this relation and Eq. (9), when

$$\bar{F}_2 = 0.6\,\bar{F}_1\,\angle -45^\circ \qquad (13)$$

the base currents in the array must be related by

$$\bar{I}_2 = 0.912\,\bar{I}_1\,\angle +167.5^\circ \qquad (14)$$

Model Antenna Measurements

To verify the conclusions reached by actual field measurements, models of the two KDYL towers were constructed. In order that the field pattern measured in the models might be of use in furnishing information, it was necessary that the base current relations be known. A simple property of transmission lines made this possible. Figure 7 shows a transmission line terminated in an arbitrary impedance, and fed with a generator at the other end. At some point ($x=0$), we designate the current and voltage as $\bar{I}_o$ and $\bar{E}_o$. Then at a point x units toward the generator the voltage is

$$\bar{E}_x = \bar{E}_o \cos\left(\frac{2\pi x}{\lambda}\right) + j\bar{I}_o Z_o \sin\left(\frac{2\pi x}{\lambda}\right) \qquad (15)$$

where Z_o is the characteristic impedance of the line and λ is the wavelength. When $x = \lambda/4$,

$$\bar{E}_x = j\bar{I}_o Z_o \qquad (16)$$

and when $x = 3\lambda/4$,

$$\bar{E}_x = -j\bar{I}_o Z_o \qquad (17)$$

Stated more simply, the voltage at a point on a transmission line is equal to the product of the characteristic impedance and the current at another point which is an odd number of quarter waves further along the line. The voltage and current are in time quadrature. The ratio of current to voltage and the phase relation is independent of the value of the load impedance or the standing wave relationship on the line.

The model antennas were then fed from an oscillator by means of the concentric transmission lines shown in Fig. 8. In this figure, E_o is the common voltage at the junction of the transmission lines. Thus, if the two lines are each odd multiples of a quarter wave in length, and are equal in length, the two antenna currents will be forced to be equal in magnitude and in phase with each other, even though the antennas have widely different impedances and large mutual impedance exists between the antennas. If the two lines are each odd multiples of a quarter wave in length and differ in length by one-half wave, the currents in the antennas will then be equal in magnitude, but will be directly out of phase with each other (180 deg.).

The arrangement of Fig. 8 was placed on a rotating metal plate on a turntable. A receiving antenna, field intensity meter, and an Esterline Angus recorder were placed a good many wavelengths away from the transmitting antenna system, as shown in Fig. 9. The field intensity was thus recorded as a function of the angle of rotation of the transmitting antenna system.

With the antennas fed with equal and in-phase currents, the broken curve of Fig. 10 was obtained. A number of field intensity ratios and phase angles were substituted in the field intensity equation to find the best fit with the theoretical curve. The solid curve on Fig. 10 represents the best fit, obtained from the formula

$$\frac{1 - 0.65\,\angle -30^\circ + 233^\circ \cos\phi}{1.65}$$

When the antennas were fed directly out-of-phase and with equal currents, the broken curve of Fig. 11 was obtained. The best fit was obtained from

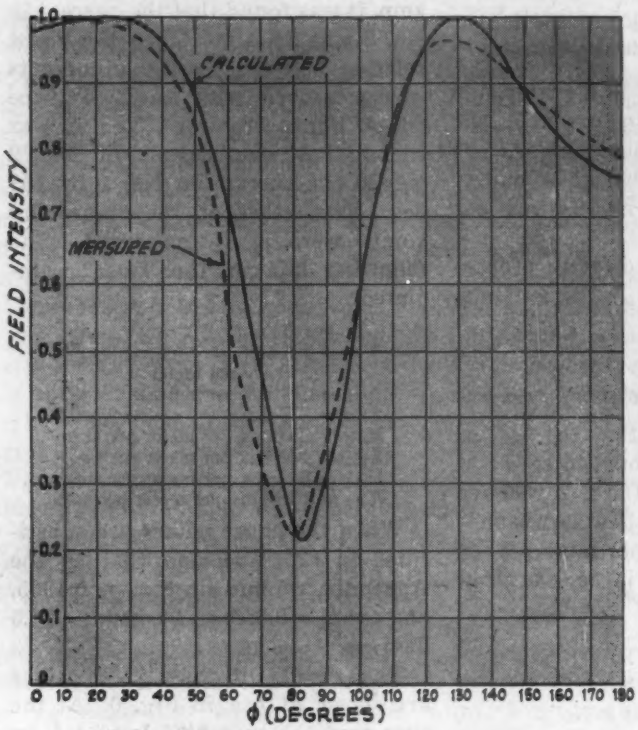


FIG. 10—Measured curve obtained when rotating model antennas were fed with in-phase equal currents, and best obtainable calculated curve

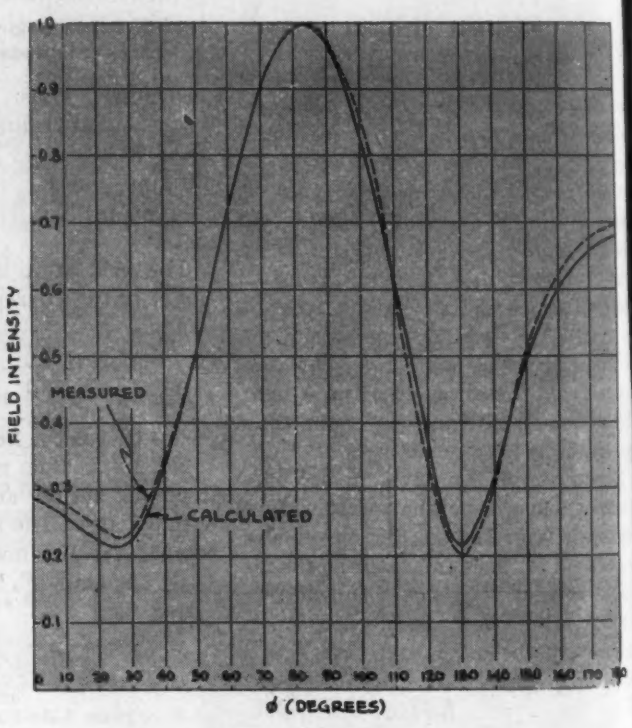


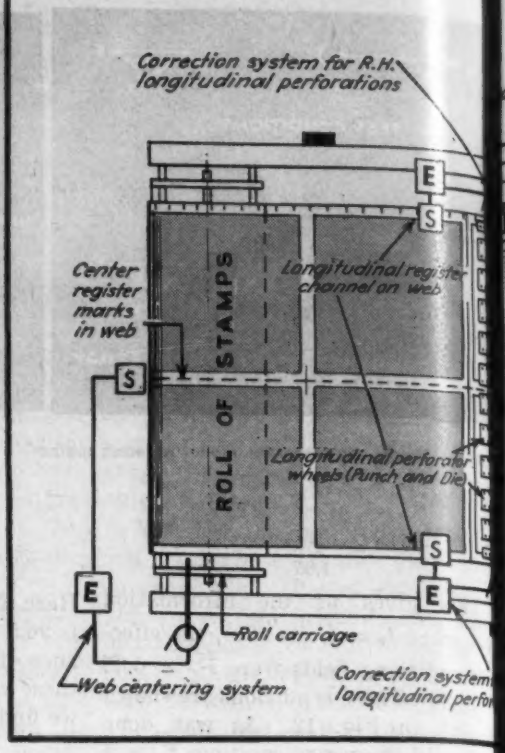
FIG. 11—Measured curve obtained when rotating model antennas were fed with out-of-phase equal currents, and best possible calculated curve

PHOTOTUBES Control Perforating Of U. S. Stamps

Rolls of printed and gummed U. S. postage stamps are accurately perforated and cut into 400-stamp sheets at the rate of 200 sheets per minute by phototubes and thyratron-controlled motors responding to printed marginal register marks

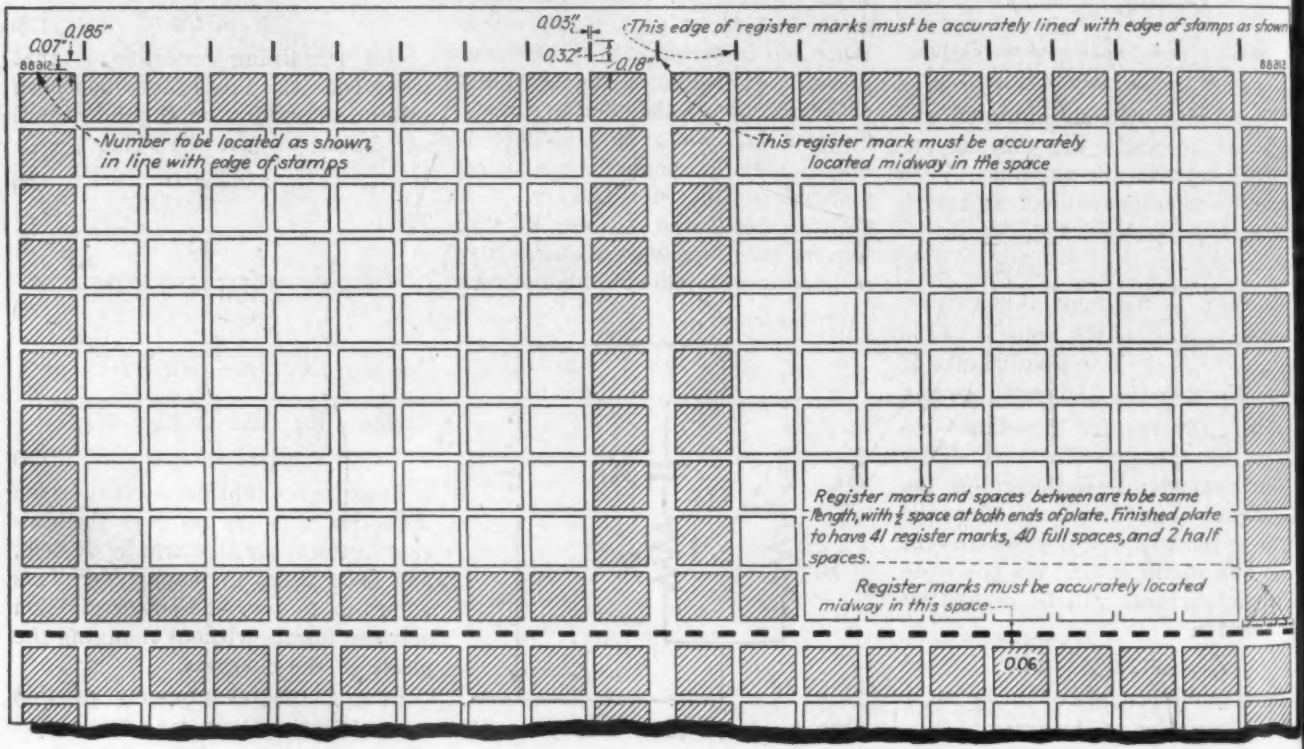
By A. W. HALL

Director
Bureau of Engraving and Printing
Treasury Department
Washington, D. C.

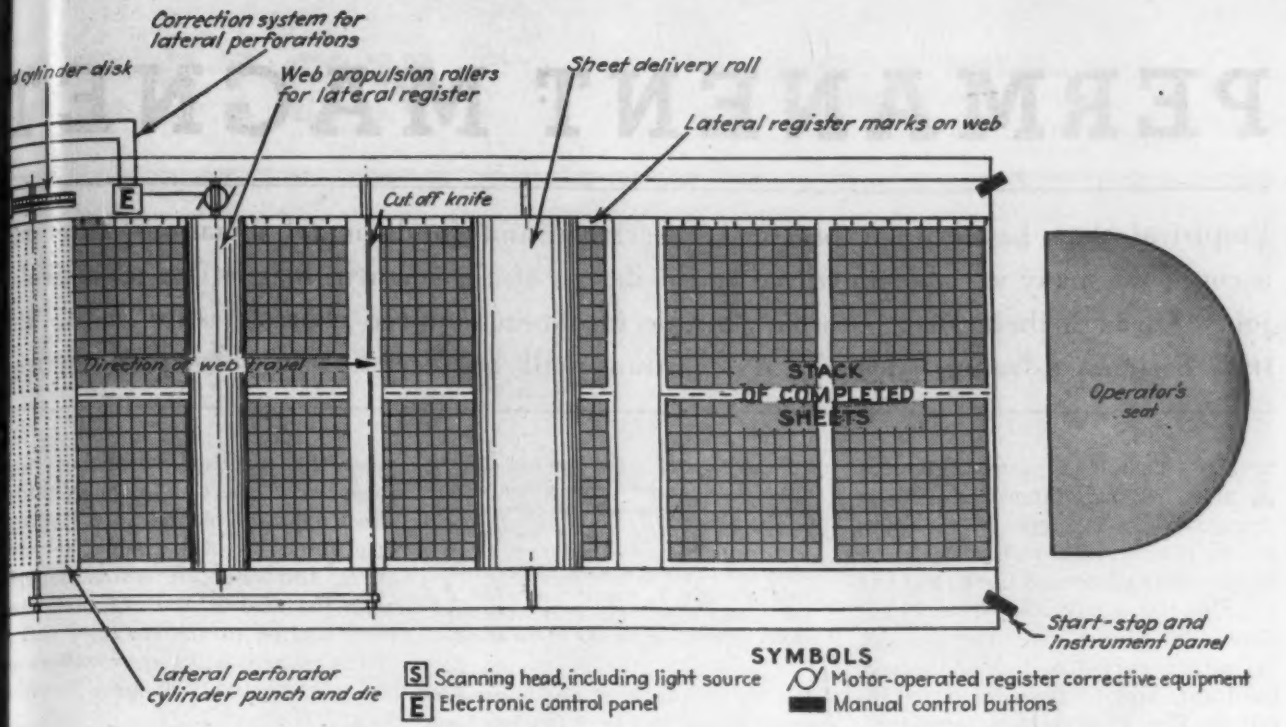


ABOVE AT RIGHT: Functions of the electronic register control on the stamp perforating machine now in use at the U. S. Bureau of Engraving and Printing. Five phototubes, each in its own scanning head S, are used

BELOW: Arrangement of a 400-stamp sheet of U. S. stamps, showing sizes and positions of register control marks in margins


0.185"
0.07"
0.03"
0.32"
0.18"
This edge of register marks must be accurately lined with edge of stamps as shown
Number to be located as shown, in line with edge of stamps
This register mark must be accurately located midway in the space
Register marks and spaces between are to be same length, with ½ space at both ends of plate. Finished plate to have 41 register marks, 40 full spaces, and 2 half spaces.
Register marks must be accurately located midway in this space
0.06

POSTAGE STAMPS are printed by the steel plate intaglio process on a web-type rotary press. This process requires that the paper be wetted to soften it in order that it may be depressed into the fine lines of the steel engraving to pick up the ink from the plate. The sequence of printing and gumming is completely



automatic and the rotary presses deliver the work in a continuous web approximately three thousand feet in length, wound on rolls. Such a roll will contain eighteen hundred sheets of four hundred stamps each sheet.

A roll of blank paper is placed in the rotary press and threaded through the various mechanisms. Briefly, the operation consists of wetting the paper, applying the printed impression, and then passing the web over an electrically heated chute where the moisture is dispelled and the ink is set. The web continues through a series of rollers where the gum is applied to the reverse side, following which it is conveyed through an electrically heated chamber where the gum is dried and final drying of the ink takes place. The operation is concluded in the automatic winding into rolls.

The next operation is the perforation and shearing into sheets of four hundred stamps each. The registrations of this operation are electronically controlled.

Perforating Problems

In the wetting of the paper for the original printing operation, drying, gumming, and redrying, the paper is subjected to varying degrees of expansion and contraction. Several factors contribute to these variations, such as temperature, atmospheric conditions, and water repellency of the paper. It becomes obvious, therefore, that the work on the delivered rolls will vary in dimensions. This variation in length of the impressions is cumulative. Under some conditions the length will be shorter than the average and under other conditions, longer. Discrepancies of 3/32 of an inch in length per impression are not uncommon. The width of the web or sheet is also subject to variation, which has been found at times to be as much as $\frac{1}{4}$ inch. These variations require continuous adjustment in the perforator mechanism to keep the perforations within the limits provided between stamps. Furthermore, variations of positioning of the printed work on the web and in the rolls as delivered from the rotary presses require correction of the roll position in delivering the web to the perforator.

The work of the perforator with which we are now concerned consists of trimming, perforating, and cutting the web into sheets of four hundred stamps each. The present method is the result of gradual developments originated by the Bureau of Engraving and Printing as far back as 1932, at which time equipment was designed and built for part manual and part electronic control. The present equipment is operated at a normal output of two hundred 400-subject sheets per minute and requires a web speed of approximately 340 feet per minute. The equipment is capable of delivering 220 sheets per minute or a web speed of approximately 368 feet per minute. The original designs obtained correction through mechanical relays operated by the electronic scanning heads, at a much slower web speed. To obtain the increased speed, the mechanical relays were replaced with thyratron tubes giving direct impulses to the differential controls.

Description of Control System

The rolls of printed and gummed stamps as received from the rotary presses described above are placed in the perforator on a carriage. This carriage has the first stage of electronic control, which is operated by a series of register marks located in the center of the sheet. These register marks are scanned by a pair of phototubes and when correctly centered, the roll carriage remains stationary. However, a slight variation in the position of these register marks will set up corresponding lack of balance through the scanning tubes and initiate the movement of

(*Continued on page* 315)

PERMANENT MAGNET D

Empirical data based upon practical experience and fundamental equations take into account the many variables involved in the design of a permanent magnet for a particular job. Through their use it is often possible to obtain required characteristics in the first trial design. Advanced design considerations will be discussed in subsequent articles

IN THE DESIGN of permanent magnets, we are interested in the demagnetization curve of the particular magnet steel at hand and not in any other portion of the hysteresis loop. In the complete hysteresis loop shown in Fig. 1 (a), the demagnetization curve is in the second quadrant, and is reproduced by itself in Fig. 1 (b). It is important that the reason for this concentration of interest be understood clearly.

Any permanent magnet which is working (i.e., supplying useful flux to an air gap within which is located an object requiring this flux) is working somewhere on its demagnetization curve. A moment's reflection and a glance at Fig. 2 will show why this must be.

EDITOR'S NOTE: The terminology of magnetism is in some ways unique. For those who feel the need of review, the author has prepared a brief explanation of magnetic phenomena and terms, giving clear and simple definitions of flux lines, field strength H, magnetic induction B and related terms. This short "refresher course" appears at the end of this article.

Let us assume that the horseshoe magnet shown in Fig. 2 (a) has been saturated and the magnetizing field removed. The flux path is closed by the soft steel bar (usually called a keeper) across its poles, and there exists no demagnetizing influences upon the magnet. Since H is zero, the flux density in the magnet is at the point B_R of Fig. 1.

If a slot is cut through the keeper as shown in Fig. 2 (b), the magnetic poles thus exposed on the cut surfaces will exert a demagnetizing effect upon the magnet. Putting this in different words—a negative value of H, the value of which depends upon the size of the cut, will have been applied to the magnet, and B in the magnet will lie somewhere on the demagnetization curve between B_R and H_C.

The value of B can never be less than zero in a working magnet since the only demagnetizing force exerted is that of the air gap, which would be zero when B is equal to zero. In other words, the only demagnetizing influence on the magnet is a sort of self-inflicted one which weakens as the flux density in the magnet approaches zero, and which could never reverse the polarization of the magnet.

The above applies only to magnets in the working circuits of which air gaps alone appear as the demagnetizing influences. What has been said applies only in part to magnets for motors, generators, magnetos and other devices which have heavy, nonuniform additional demagnetizing influences originating in the current flowing in their coils. The analysis of these slightly more complicated cases will be taken up in the next article of this series.

The intersection of the demagnetization curve with the B ordinate, which we have designated as B_R, is usually called the "residual flux density," while the intersection of the

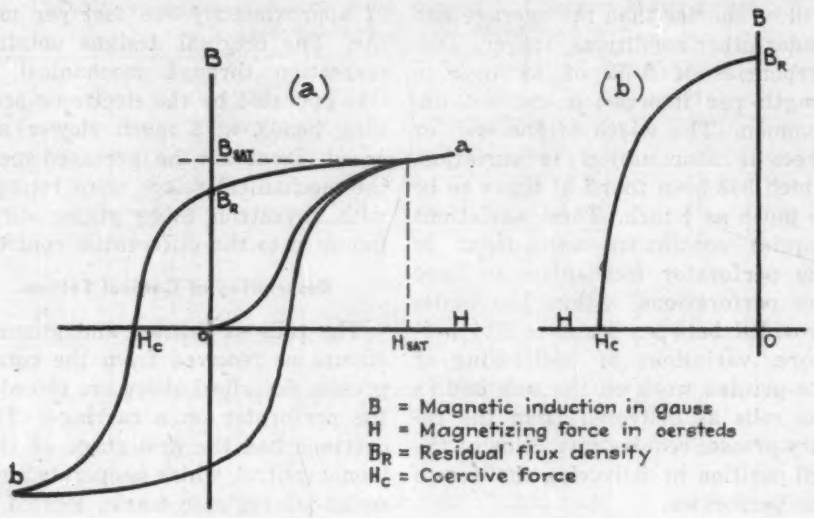


FIG. 1—(a) Complete hysteresis loop. (b) Second-quadrant demagnetization curve, reproduced by itself

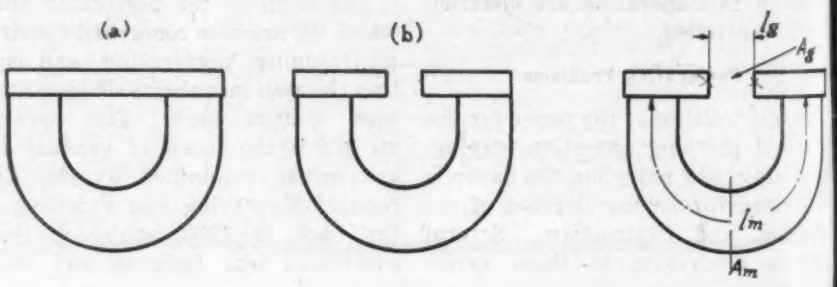


FIG. 2—(a) Horseshoe magnet with flux path closed. (b) With slot cut through keeper, exposing poles and exerting a demagnetizing effect upon the magnet

FIG. 3—(extreme right) Simple magnetic circuit, consisting of a permanent magnet, a pair of pole pieces and an air gap

DESIGN

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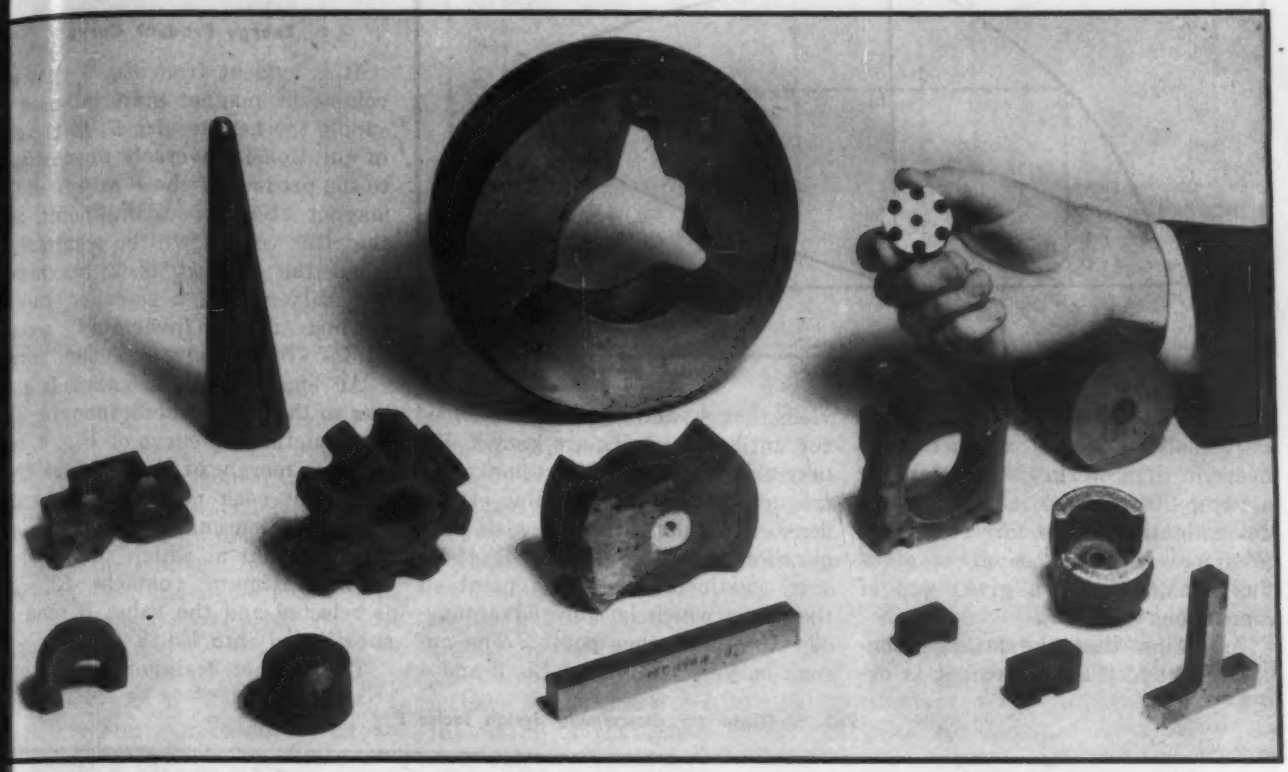


Typical permanent magnets, intended for a wide variety of uses in electronic and electrical gear

urve with the H ordinate, which we ave designated H_c, is usually called he "coercive force" of the material n question.

Design Equations

Now, consider the magnetic circuit hown in Fig. 3, consisting of a permanent magnet, a pair of soft iron ole pieces and an air gap.

The magnet has a certain length esignated by l_m, and a certain area, A_m. The area (which we are, for the oment, assuming to be constant hroughout the length of the magnet) is that of a section taken perpendicularly to the length. Likewise, he air gap has a certain length, l_g, nd a certain area, A_g. Let us also ssume for the moment that A_g is qual to the area of the exposed soft ron pole face, although we shall see ater that this is not necessarily so n this general case.

For the purposes of the following discussion, let us disregard leakage nd assume that all the flux lines in he magnet cross the air gap. This ssumption permits us to write that the flux in the gap is equal to the flux in the magnet, or $\phi_g = \phi_m$. Since $\phi = BA$ when the flux density is uniform over the area, we get

$$B_g A_g = B_m A_m \qquad (1)$$

Now, again referring to Fig. 3 and still assuming no leakage, let's see how much work is done by or on a unit North pole in the various parts of the circuit.

The force exerted on this pole is everywhere an analytic function of the complex variable and hence, since Cauchy's Integral Theorem states for this condition that the line integral about any closed curve in the region is equal to zero, it follows that the total work done *by* a unit North pole moving through the length of the magnet is exactly equal to the total work done on the pole moving through the gap. If this were not true, we should have in a magnet a source of energy capable of continual dissipation with no change in original value—an infinite reservoir of magnetic energy.

Since field strength H is defined as the force exerted upon a unit pole (and still assuming no leakage), we may write $H_g l_g = H_m l_m$. In air, $B = H$, hence our expression becomes

$$B_g l_g = H_m l_m \qquad (2)$$

Leakage Constants

Equations 1 and 2 are the complete design equations for a permanent magnet system operating without leakage. The factors determining the amount of leakage that will exist in any given magnetic circuit are numerous but are concerned mostly with the geometry of the circuit and the number and reluctance of leakage paths.

Leakage may be computed quite accurately by tedious and painful methods but, in general, this is unnecessary and is seldom done by design engineers. Instead, a constant is added to each of the design equations to take care of the leakage flux, and the final design equations become:

$$F B_g A_g = B_m A_m \qquad (3)$$

$$f B_g l_g = H_m l_m \qquad (4)$$

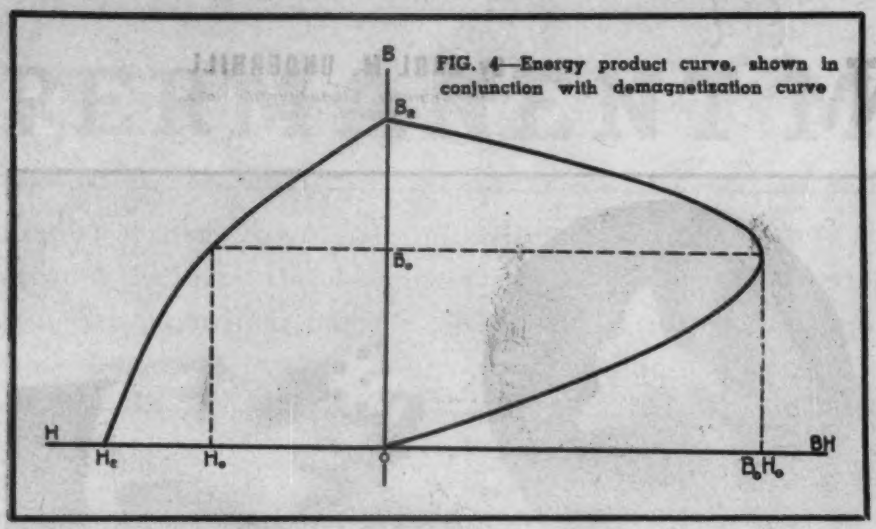


FIG. 4—Energy product curve, shown in conjunction with demagnetization curve

These are two simple equations universally used by magnet engineers in their work. Usually, but not always, the problem involved is the determination of the correct magnet area and length to supply a given flux density B_g to a given gap of dimensions A_g and l_g.

Assuming that the leakage constants F and f are known, it is obvious that A_m and l_m can not be solved for until B_m and H_m are known. We may choose B_m and H_m to make the magnet operate at any point on the demagnetization curve we wish. The question naturally arises—is there some particular operating point on the curve which is more advantageous than any other point? The answer is, yes. Rearrange Eq. 3 and 4 to make them appear as follows:

$$A_m = F B_g A_g / B_m$$
$$l_m = f B_g l_g / H_m$$

Now multiply them together:

$$Volume_m = \frac{F f B_g^2 \, Volume_g}{B_m H_m}$$

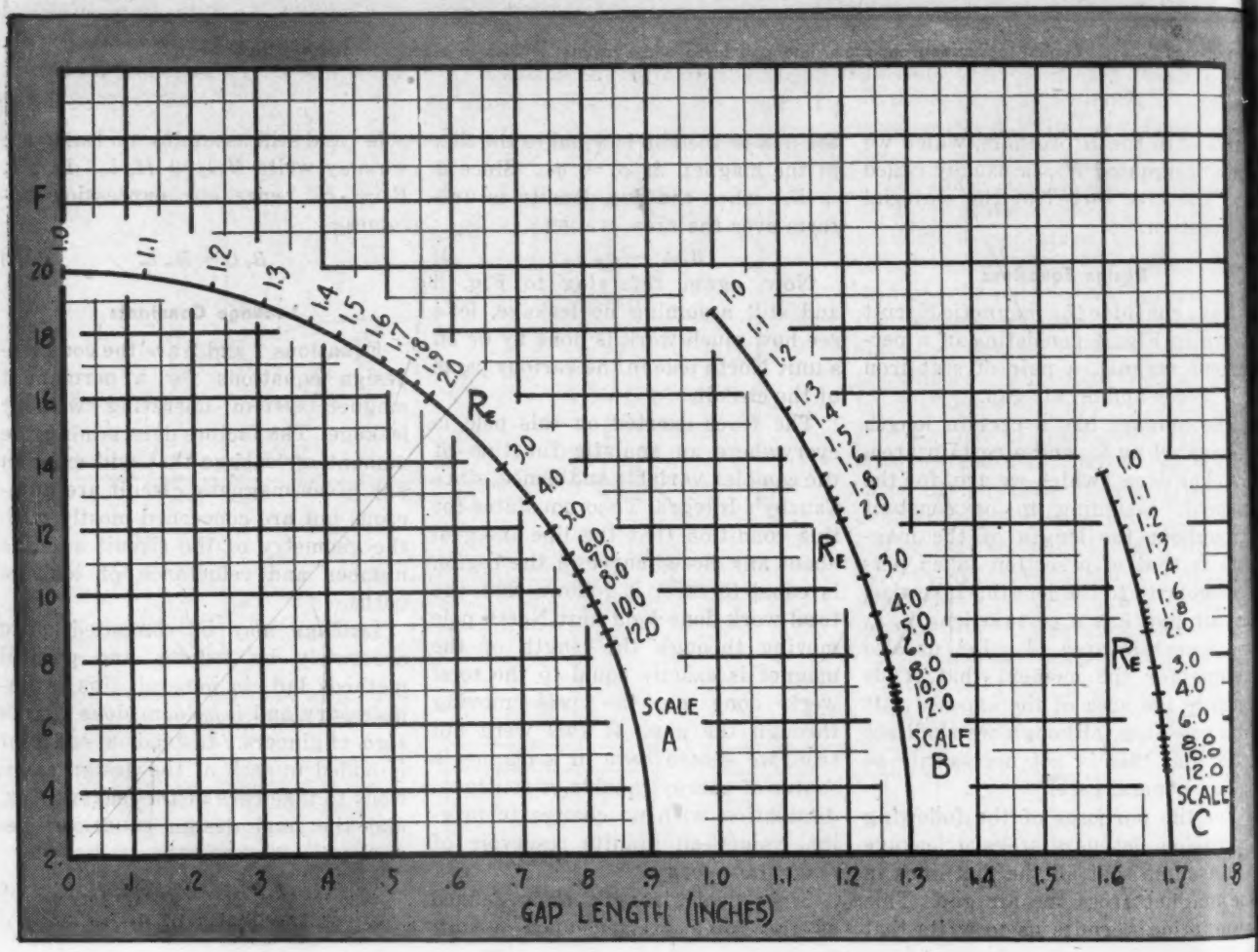
Energy Product Curve

It is evident from Eq. 5 that t volume of magnet material used supply the flux density B_g to the g in question is inversely proportion to the product of the B and H of t magnet at its operating point, a that this volume will be a minimu when the product is a maximu For this reason, a so-called ener product curve invariably acco panies every demagnetization cur

An energy product curve is si ilar to that shown accompanying t demagnetization curve of Fig. 4, a consists merely of the product of and H at each point along the d magnetization curve, plotted again B. The point at which this produ is a maximum (namely B_m, H is selected and the value B_m and substituted into Eq. 3 and 4.

The magnet designer is thus pr

FIG. 5—Graph for determining design factor F



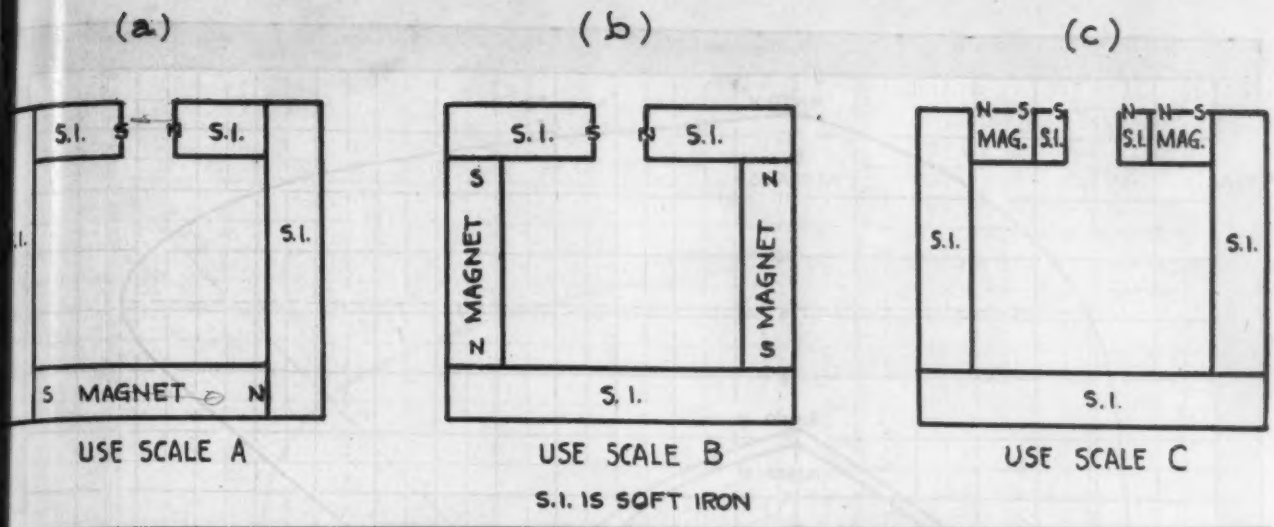


FIG. 6—Chart of magnet types, for determining proper scale to use on Fig. 5

ded with all the factors necessary solve his two design equations nce it has been assumed that F and are known, B_g and H_g may be obained from the demagnetization rve of the material he intends usg, and B_g, l_g and A_g he sets himself s the independent requisites of the rcuit.

Estimating Leakage Constants

But F and f have only been asumed to be known. Determination f their values is one of the most ifficult of all problems in permanent agnet design work.

The total amount of leakage is a unction of the geometry of the ciruit, i.e., the size and number of agnets and soft iron pieces conituting the circuit proper, the geoetrical relationship of these units o the working air gap, and the size, umber and relationship of adjacent agnets and other ferromagnetic aterial. Thus, not only are the varitions infinite in number but the situation calls for an exact knowledge of what the circuit will be before an accurate estimate can be made of what the leakage will be. Obviously, we can not know the exact size of the circuit before we know the size of the magnet or magnets we are going to use—and hence we go around in a circle.

The classical answers to this dilemma are two in number. The first involves a guess as to what the final circuit will look like, followed by a laborious determination of all leakage paths involved, a trial and error method of determining gap flux density from an assumed magnet flux density, and revision of magnet size and repetition of this cycle until the correct gap flux is obtained. This method, after some practice and experience, may be made to yield quite accurate results.

The alternative answer is the simple statement that magnet design is an art, not a science, and that only highly specialized experience can enable an engineer to properly evaluate leakage. Specialized experience in the design of permanent magnets is of greatest value in any estimate of leakage. However, the writer has evolved a method that will enable any engineer to arrive at reasonably accurate values of F and f for any given design problem. This method is wholly empirical and will not yield great accuracy, but it does provide a useful approach to the problem of finding the elusive leakage constants for most ordinary circuits.

Since f is the simpler of the two, let's look at it first. The value of f varies only over a relatively small range, usually from a minimum of 1.2 to a maximum of 1.5, and the extremes are seldom met in practice. A value of f equal to 1.35 is a good engineering guess for this constant for almost any permanent magnet circuit.

The value of F has a much greater range. Its lower limit is approximately 2.0, while its upper limit is nonexistent. Theoretically, F may be infinitely large, but in practice it usually varies between 2.5 and 10.0.

While it is a fact that theoretically the designer knows only the size of the working gap and the flux density which he wishes to establish in this gap, he usually has some idea of the size of the rest of the circuit because of space considerations in his equipment.

The first step in determining F is to lay out at full scale on a piece of paper the closest guess it is possible to make as to the actual size of the completed circuit. Next, draw a pair of complete circles in such a way that, when they are placed over the outline of the estimated circuit, the inner circle will conform roughly with the inside contour of the circuit and the outer circle will conform roughly with the outside contour of the circuit. Designate by R_E ($R_E > 1.0$) the ratio of the diameter of the two circles, and spot this point on the proper scale in Fig. 5.

Use of Graphs

It may be determined from Fig. 6 whether scale A, B or C is to be used in Fig. 5. If the designer plans to make his circuit with the pole faces of the magnet parallel to the faces of the gap but with the direction of magnetization of the magnet opposite in sense to that of the gap as shown in Fig. 6 (a), he should use scale A. If the pole faces of the magnet are to be perpendicular to those of the gap as shown in Fig. 6 (b), he should use scale B. If the pole faces of the magnet are parallel to the gap and with the direction of magnetization of the magnet in the same sense as that of the gap as shown in Fig. 6 (c), he should use scale C.

With the proper value of R_E located on the proper scale of Fig. 5, it is then necessary only to draw a straight line between this point and the point (0, 2) located at the intersection of the heavy abscissa and

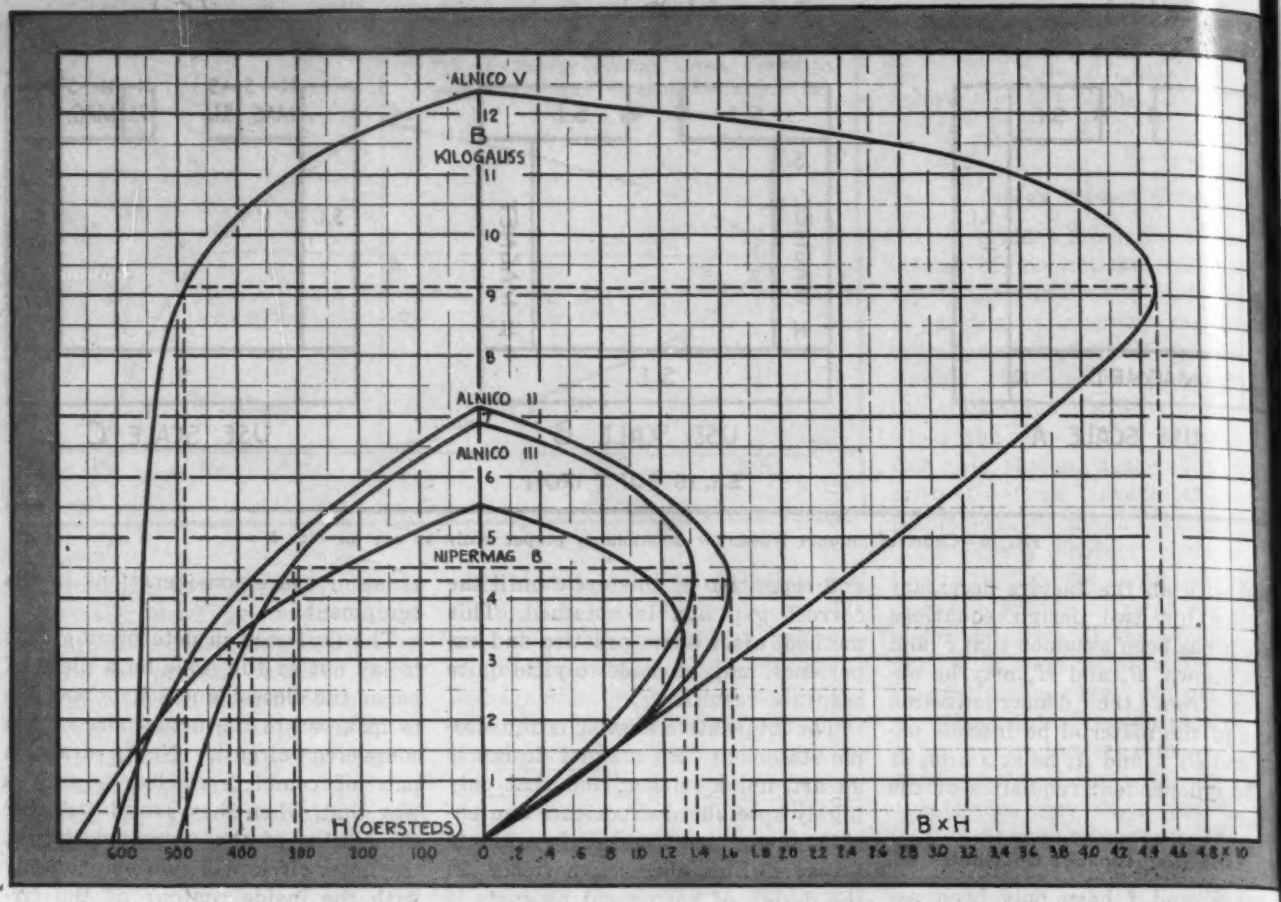


FIG. 7—Typical demagnetization and energy product curves for various alloys manufactured by the author's firm

ordinate. From the straight-line graph thus formed, the value of F may be picked for the proper value of gap length.

The writer wishes at this point to emphasize his earlier warning that despite any impressiveness which may attach itself to Fig. 5, the method is entirely empirical and great accuracy must not be expected. The method was devised originally to serve the interest of the designing engineer who has had little previous experience with permanent magnets. By its use, such an engineer will be able to obtain a magnet design which will be fairly close to requirements.

Testing a Sample

Having empirically arrived at a suitable design and having made up a sample magnet assembly, it is a simple matter, by measuring the total flux in the gap and in the neutral section of the magnet, to obtain an accurate value of F (Eq. 3 shows that F is the simple ratio of these two quantities). At the same time, since the areas of the gap and magnet are known, the flux densities are known, and f may then be calculated accurately with the aid of design equations and a demagnetization curve of the magnet material used.

At this point an accurate re-design of the magnet is possible, if necessary, to give the designer something extremely close to the exact circuit he wants.

Typical demagnetization and energy product curves for various alloys manufactured by Cinaudagraph Corporation are given in Fig. 7 for use in connection with this magnet design procedure.

Use of Nomograph

The nomograph in Fig. 8 makes possible a mechanical solution of the design equations superimposed upon the demagnetization curves of Fig. 7. This is a convenient tool as it presents all in one picture the three simultaneous equations to be solved in any design problem, namely the two design equations and the demagnetization curve of the material to be used.

Related problems such as (a) Given the magnet size, alloy and gap size, what will be the flux density in the gap, or (b) Given the magnet si and gap size, what will be the be alloy to use to give maximum flu density in the gap, may be easil solved with the aid of this figure.

When using the nomograph straight-edge must be laid acros from X to X' or from Y to Y'. Whe this is done, the three quantitie marked by the intersection of th straight-edge with the three scale involved all bear the correct relatio ship to each other.

Meter Magnet Design

To illustrate the procedure pre sented in this article, some typica problems in permanent magnet de sign for meters will now be given.

Let us suppose that an instrumen manufacturer, desirous of doublin the sensitivity of one of his instru ments and redesigning to take ad vantage of the latest improvement in permanent magnet steels, decide to obtain the doubled sensitivity by leaving the sizes of the gap and the moving coil as they were and simply doubling the flux density in the gap. Let us suppose, furthermore, that the old model had a 0.500-in. core, a

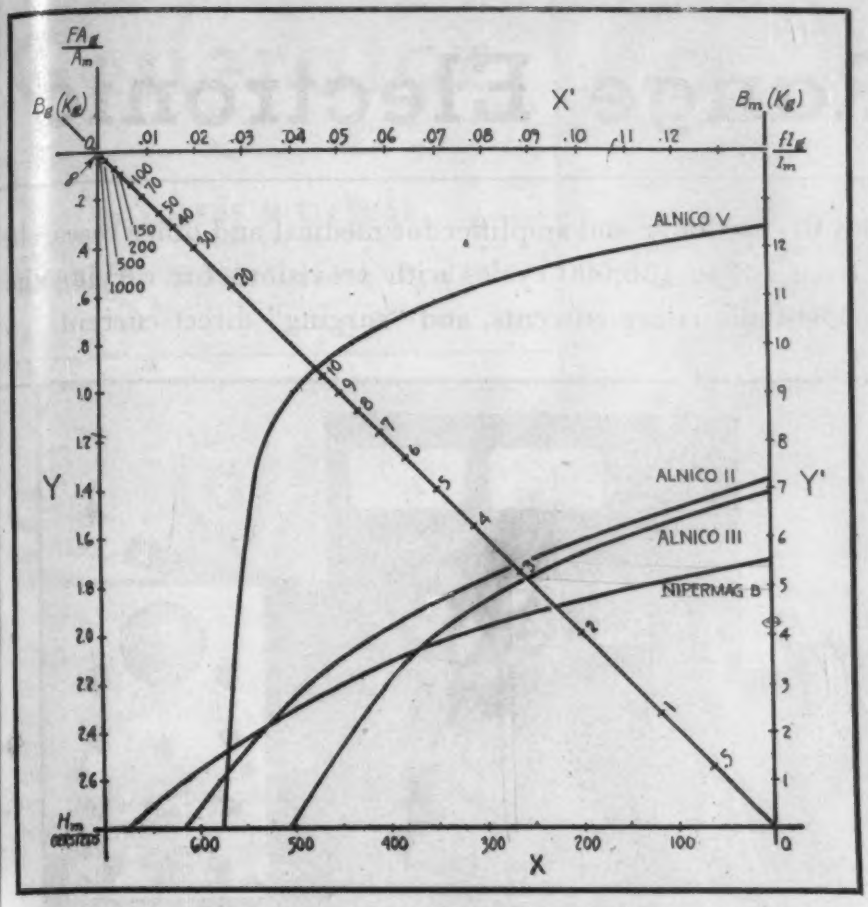


FIG. 8—Nomograph permitting mechanical solution of design equations superimposed upon Fig. 7

0.125-in. gap, and a flux density of 1750 gauss. The problem is to design a permanent magnet to supply the above-mentioned gap with 3500 gauss.

The first step is to lay out the air gap to scale, and our best guess as to what the rest of the circuit will look like. This has been done in Fig. 9. Figures for the magnet size have been picked out of the air and may or may not be close to the eventual size. Two circles have been drawn on the figure to conform approximately with the inside and outside contours of the circuit. (When drawing a circle to conform to an irregular contour, the area of the circle should be made approximately equal to that enclosed by the irregular contour.)

The ratio of the diameters of these circles turns out (by measurement) to be equal to $R_r = 2.25$. Since this is a type A circuit (refer to Fig. 6), the value $R_r = 2.25$ is marked off on scale A of Fig. 5 and a straight line drawn between this point and the point (0, 2). Fig. 5 has thus become a straight-line graph, and a value of $F = 4.7$ is picked from it, corresponding to the gap length of 0.125 in.

Let us suppose that we have decided to choose Alnico II as our magnet material. We have then, with the aid of Fig. 7, all the factors necessary to the solution of our design equations: $F = 4.7$; $f = 1.35$; $B_g = 3500$; $B_m = 4300$; $H_m = 380$; $l_g = 0.125$ in. $= 0.3175$ cm.; $A_g = 112.8\ \pi\ 0.550 \times 0.500/360 = 0.270$ sq. in. $= 1.742$ sq. cm.

These values are now substituted in Eq. 3 and 4, giving $A_m = 4.7 \times 3500 \times 1.742/4300 = 6.66$ sq. cm. $= 1.033$ sq. in., and $l_m = 1.35 \times 3500 \times 0.3175/380 = 3.948$ cm. $= 1.554$ in.

These values may also be obtained with the aid of the nomograph of Fig. 8. If a ruler be laid between the points 4300 on the Y' scale and 3500 on the B_g scale, we read on the Y scale a value of 1.23 for the quantity FA_g/A_m. Similarly, a ruler laid between the points 380 on the X scale and 3500 on the B_g scale yields on the X' scale a value of 0.109 for the quantity fl_g/l_m. A_m and l_m may thus be easily determined.

Correcting First Estimates

As we look at the values of A_m and l_m just determined, we discover that our original guesses for these two quantities were greatly in error. The length, we see, has to be increased by about 50 percent and the area by about 100 percent. However, the 1-in. dimension previously assigned as the width of the magnet still looks pretty good, so we maintain this dimension when we redraw the circuit as shown in Fig. 10.

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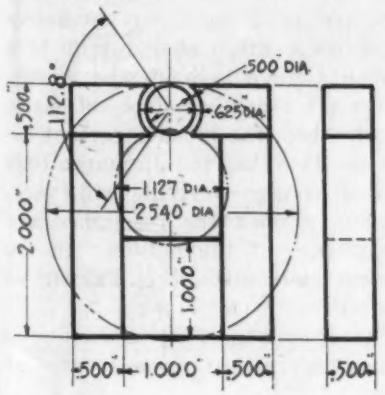


FIG. 9—Layout of proposed meter magnet to scale, the first step in redesign

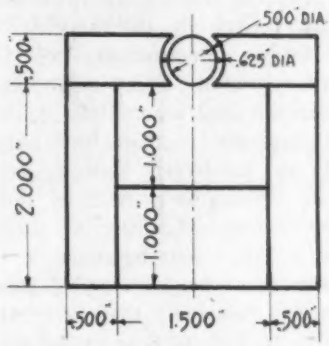


FIG. 10—Meter magnet circuit redrawn to correct initial errors

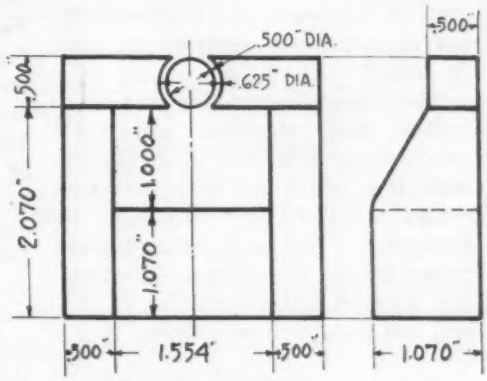
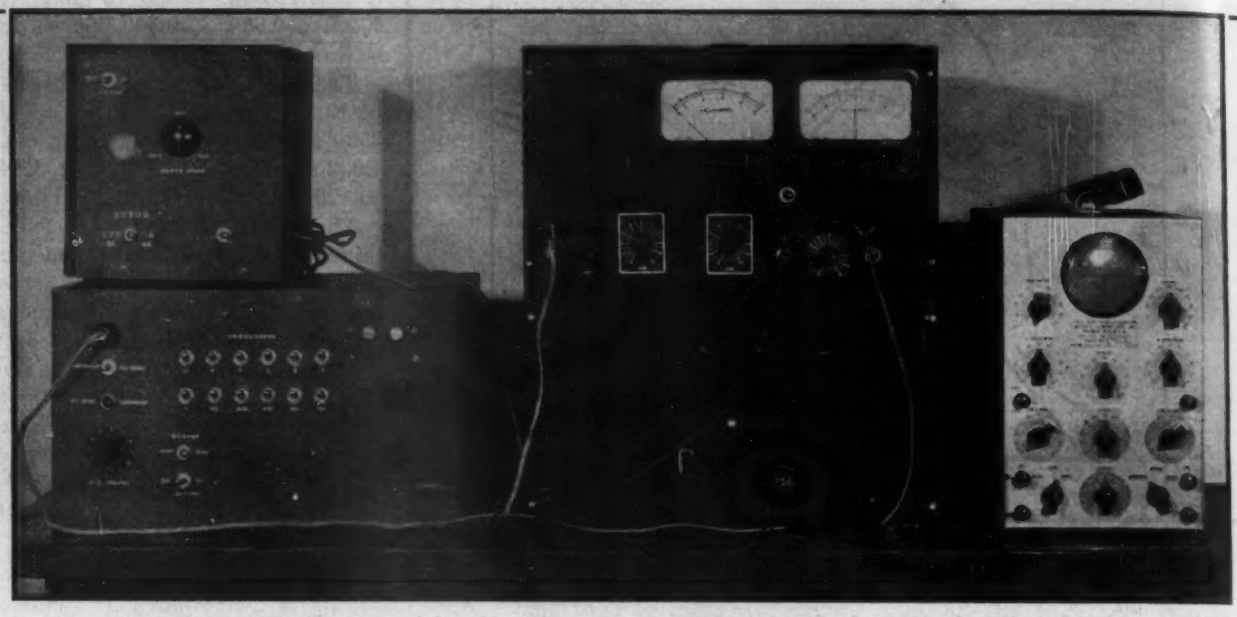


FIG. 11—Final meter magnet circuit as redesigned to take advantage of efficient new steels

Wide-Range Electronic

Circuit details of an all-purpose RC oscillator and amplifier for medical and other research, providing a frequency range from 1.8 to 180,000 cycles with provisions for varying the wave form, obtaining exponentially rising currents, and "surging" direct currents



Wide-range oscillator and amplifier with auxiliary equipment. Upper left—motor with switching arrangement for "surging" the output current; lower left—chronaxie measurement box, containing RC combinations yielding time periods from 0.001 to 5 seconds; center—oscillator and amplifier, with power packs underneath; right—oscilloscope for checking wave forms

THE APPARATUS to be described was developed in the Department of Electronic Research of the Illinois Tool Works in connection with a research project carried out in the Department of Physiology, Northwestern University Medical School.* Although the instrument was developed and is being used for electromedical purposes, it is believed that its application is by no means restricted to the medical field and that useful industrial applications may be found.

The requirements for the generator were manifold and their enumeration will best illustrate the difficulties which had to be overcome before a satisfactory unit could be completed. The unit was designed primarily for the purpose of studying the electrical excitability of normal and paralyzed muscle and to determine optimum current forms for stimulation of such muscle. The five basic requirements for such a study are given below:

(1) *Sinusoidal alternating current covering a wide frequency range.* In normal muscle, a parabolic relationship exists between the frequency of sinusoidal alternating current and the current intensity at which the first stimulation occurs. For normal frog muscle, an optimum frequency occurs in the neighborhood of 100 cps. Preliminary experiments upon humans, dogs, and monkeys indicated that a complete study of this parabolic relationship, particularly in paralyzed muscle, required an instrument with a low frequency range extending at least down to 1 cps. Furthermore, the wave form must be good at all frequencies and relatively high current values (up to 100 ma) are required throughout the frequency range. Finally, provision for "surging" or modulating this current at a rate of 5 to 60 times per minute was required.

(2) *The ability to choose any arbitrary wave form at any given frequency.*

(3) *Provision for chronaxie measurements and the plotting of strength-duration curves.* Conventionally, these values are obtained by discharging a capacitor of known capacitance after charging it to a known voltage through the muscle. There are a number of objections to this method, the most important being the fact that the discharge time and discharge current will vary, depending upon the resistance and capacitance of the muscle. In the present instrument, this difficulty is avoided.

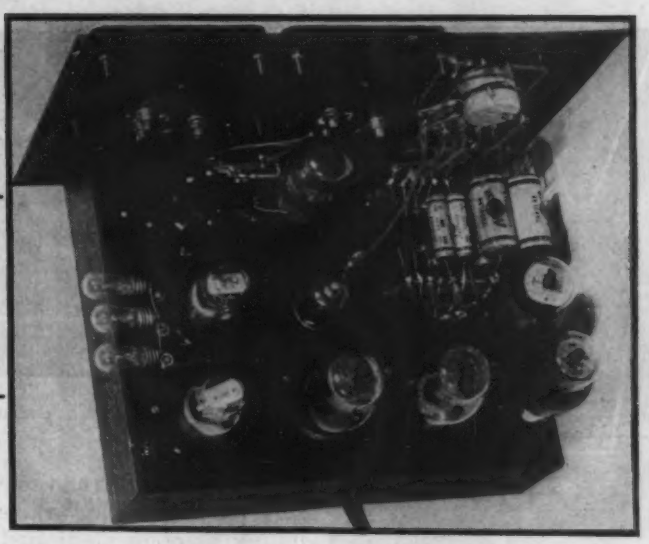
(4) *Provision for exponentially rising currents of various rates of rise.*

(5) *Provision for direct current which can be "surged" at will.*

* Aided by grants from the National Foundation for Infantile Paralysis and the Council on Physical Therapy of the American Medical Association.

Generator

By EUGENE MITTELMAN,
Illinois Tool Works
FRED S. GRODINS and A. C. IVY
Northwestern University



Top view of oscillator-amplifier chassis

The circuit diagram of the instrument is shown in Fig. 1. It consists essentially of two main units, an oscillator and an amplifier, served by two power pack circuits.

Oscillator Circuit

The two-tube *RC* oscillator has a frequency range of 1.8 to 180,000 cps, and employs a circuit that is conventional except for the fact that frequency adjustment is accomplished by variation of the resistance branches of the frequency-determining *RC* bridge rather than by variation of capacitance. The main advantage of this procedure is the instrument's ability to cover a relatively wide range of frequencies on a single scale.

If rheostats are selected with sufficiently high wattage value the accuracy of reproduction of the initial calibration is about as high as that of oscillators using variable capacitors.

Lower frequencies down to a fraction of a cycle per second can be obtained with the equipment. The method of doing this will be described in connection with the chronaxie measuring device.

Frequency multiplication is obtained by changing the values of the fixed capacitors in both capacitance arms of the frequency determining bridge. Four scales in decimal multiples cover the entire frequency range. In each range the ratio of the maximum to minimum frequency is 100 to 1 (1.8 - 180, 18 - 1800, 180 - 18000, 1800 - 180,000). A wide frequency band can be explored in each range. Thus the necessity of changing switches during an investigation is, as far as possible, avoided. This is important because in physiological work each switching is accompanied by an impulse of stimulation.

A variable feedback control is provided between the first and second tubes. This serves two purposes: first, to secure stable oscillation over extreme frequency ranges, and second, to change the wave form. Variable feedback allows the arbitrary setting of any wave form between a square wave and a sinusoidal wave. The change in amplitude which necessarily must accompany change of feedback in certain regions can be compensated for by the use of the volume control between oscillator and amplifier.

Amplifier Circuit

A switching arrangement in connection with a terminal block between oscillator and amplifier allows a choice between oscillator input and that from an outside source. This is

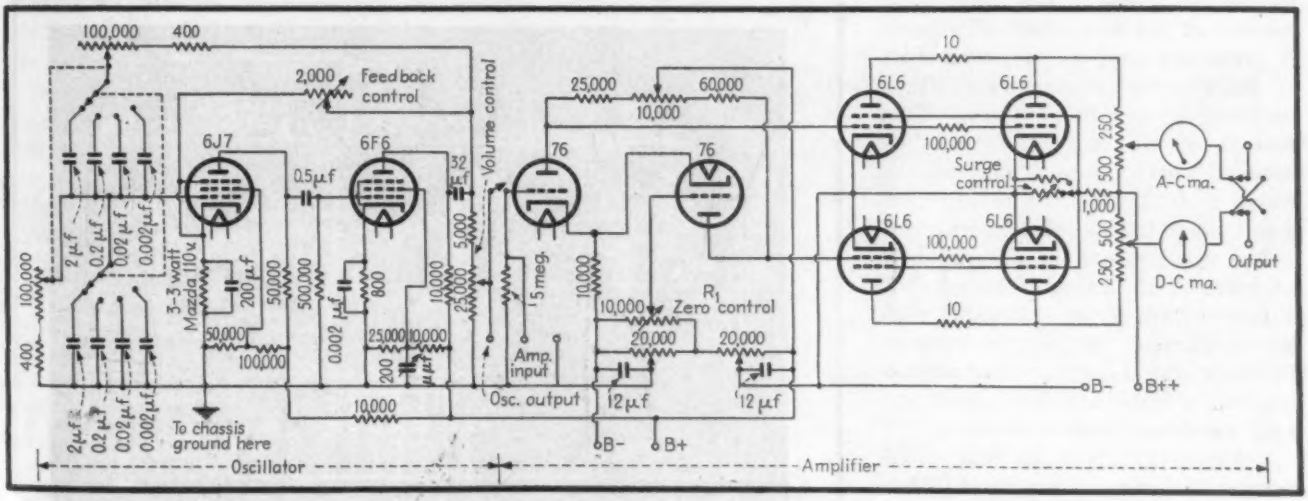


FIG. 1—Circuit diagram of wide-range RC oscillator and amplifier. A type 5Z4 is used in the power pack for the oscillator, and a type 83 serves the amplifier, both being connected for full-wave rectification in conventional circuits (not shown)

FIG. 2—Samples of wave forms obtainable

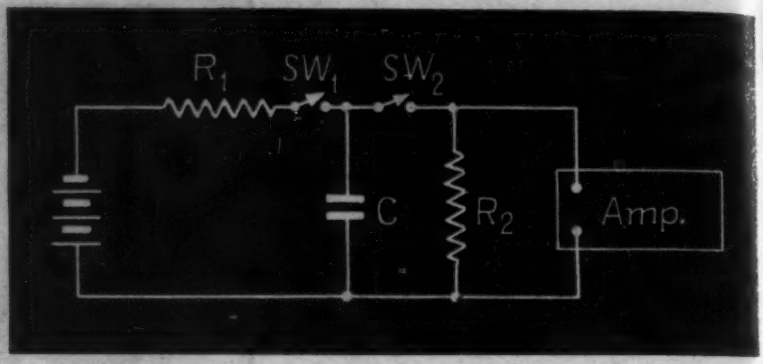


FIG. 3—Simplified circuit illustrating principle of chronaxie measurement

important because in some instances a variable direct current must be used while in others chronaxie measurements must be taken.

The amplifier input stage contains two type 76 tubes, one serving as a phase inverter and the other as a voltage amplifier, feeding four 6L6 tubes in push-pull parallel. The phase-inverting stage and the output stage are so balanced that for zero voltage across the input terminals of the amplifier input both the alternating and direct current components in the output stage are zero.

The direct current component in the output stage is the differential current of the two push-pull stages. A variable rheostat R_1 allows a shift of the d-c component toward either positive or negative values. This feature of the instrument may be used to obtain output currents in which a d-c component is superimposed upon the alternating current.

The oscillograms in Fig. 2 show currents of the same frequency but different wave form, obtainable with the instrument. Either the variable feedback, the d-c differential adjustment or a combination of both was used to obtain these curves.

The output leads of the final amplifier are in series with a d-c milliammeter and a thermocouple-type a-c instrument. When impressing symmetrical voltages on the amplifier input, the d-c instrument will show zero reading for any value of alternating current indicated by the thermocouple instrument. Similarly, any d-c component which is imposed upon the output by means of the rheostat R_1 is indicated both as to amplitude and polarity by the zero-center d-c instrument. This instrument also indicates the degree of asymmetry of wave forms. The meters thus provide a quick check of wave forms, to supplement the oscilloscope ordinarily across the output.

Surging Arrangement

In biological work it is often desirable that the supplied current shall reach its maximum amplitude slowly and then decrease again to zero. This procedure is usually called "surging" in electromedical terminology. In the unit under discussion it is accomplished by periodically changing the screen-grid voltage of the four-tube output stage.

The variable resistance marked "surge-control" is in series with a 1000-ohm fixed resistor. The variable resistor is of the continuous wound type, with a slider capable of rotation without interruption. During each full 360-deg. rotation the resistance between any fixed point on the circumference of the variable rheostat and the rotating slider will reach zero once and pass through a maximum value once. The maximum resistance is so selected that in connection with the 1000-ohm fixed resistor it will provide the proper screen grid voltage for maximum output of the four beam-power tubes. A switching arrangement permits replacing the rheostat with a fixed resistor providing maximum output.

Chronaxie Measurements

A few words should be said about chronaxie measurements. The principle used is best explained with reference to Fig. 3. When switch SW_1 is closed, capacitor C charges

(*Continued on page* 322)

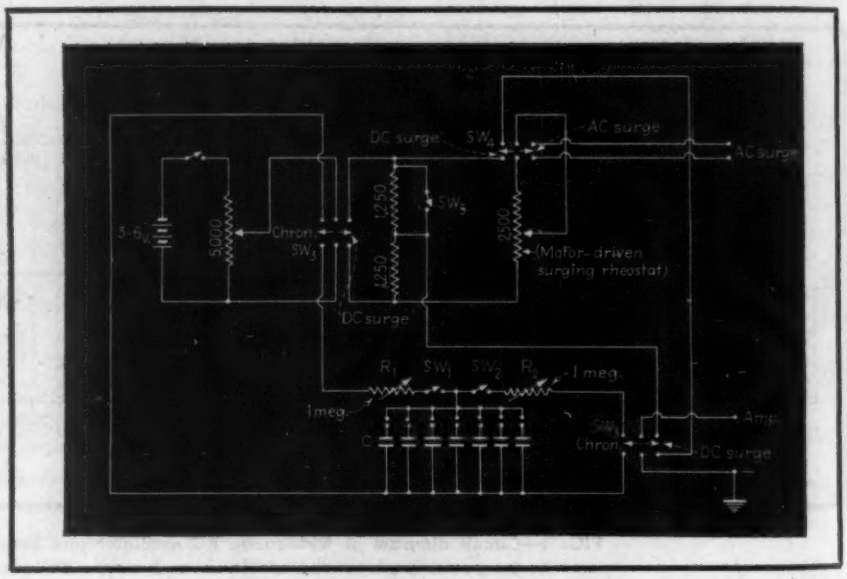


FIG. 4—Chronaxie measurement circuit

Volume Compressor for Radio Stations

By GEORGE Q. HERRICK
Chief Engineer
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New York City

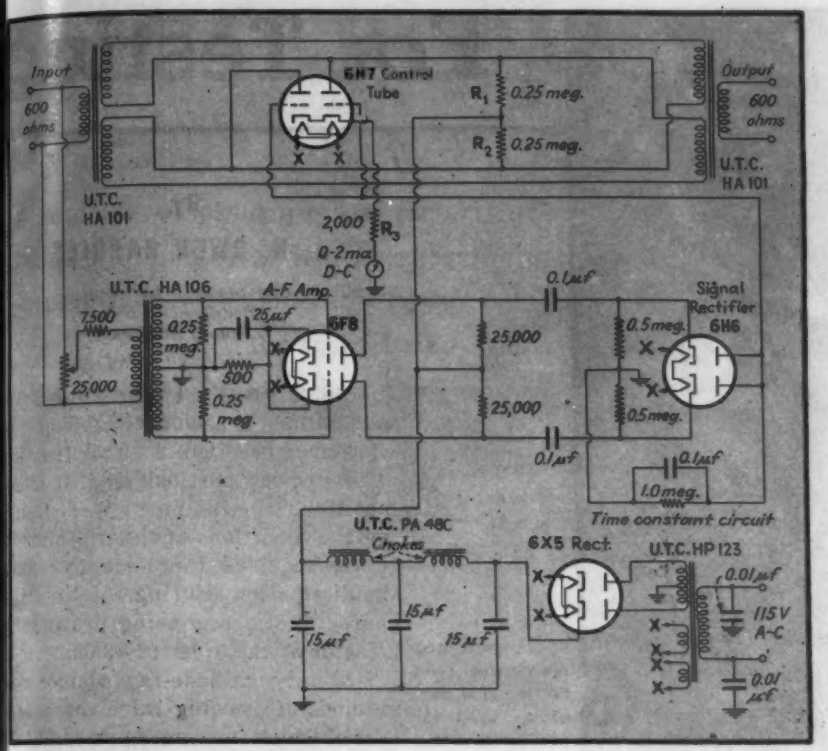

FIG. 1—Circuit diagram of volume compressor developed by George Herrick for use on the audio lines of the OWI master control center in New York City

A unique audio compressor circuit that permits boosting the average percentage modulation of a short-wave transmitter up to 90 percent. Response is flat to 14,000 cycles

THE preponderance of sudden volume peaks in foreign-language programs and the desirability of operating U. S. short-wave transmitters with the highest possible average percentage modulation for effective competition in international broadcasting made it highly desirable to use volume compressors on all programs passing through the new master control center of the Office of War Information in New York City.

The special compressor circuit developed for this purpose is shown in Fig. 1. The input and output transformers are standard models, connected as shown at (a) in Fig. 2 so that the windings have the indicated polarity. Between the cross-wires at P are resistors R_1 and R_2, each shunted by one section of the 6N7 double-triode control tube.

Under normal conditions, when there are no peaks, the combined resistance of R_1, R_2 and the tube is low because the triode sections have a small negative bias (only developed across the 2000-ohm cathode resistor) and hence have fairly low plate resistance values. The two crossed wires can then be considered as connected together at P, placing the windings in series aiding as in Fig. 2b and giving signal transfer from input to output as required. The insertion loss under this normal condition is only 7 vu, easily made up in other amplifiers.

The input signal is also applied through the 25,000-ohm potentiometer to the 6F8 push-pull voltage amplifier stage, providing input voltage for the 6H6 signal rectifier tube. Diode plate current develops across the time constant circuit a voltage drop that acts in series with the automatic C bias voltage across R_3 and aids that voltage, thereby driving the control tube grids more negative. Under normal-signal conditions, this merely drives the operating point slightly farther down on the characteristic curve without bringing it to cutoff.

Signal peaks increase the plate current through the time constant circuit of the signal rectifier in proportion to signal peak intensity, thereby increasing the negative bias on the control tube. As this bias approaches the cutoff value, the plate resistances increase rapidly and the feed-through circuit approaches that shown in Fig. 2a, where there is no

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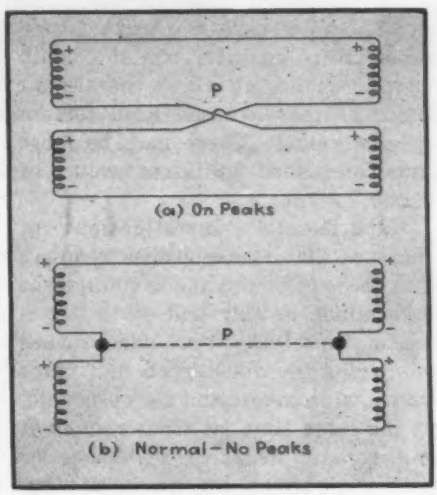


FIG. 2—Simplified diagrams of transformer connections

IMPULSE GENERATOR For Testing H

By

J. H. OWEN HARRIES

Electronics Department
Rediffusion, Ltd.
London, England

Spark gaps and resistances of the impulse generator used for producing voltage pulses up to 75,000 volts

MANY modern electronic oscillators operate only at certain anode voltages at which the transit times of the electrons have certain specific values. There may be more than one such optimum value of anode voltage.

Experimental investigation of these oscillators sometimes requires that these optimum anode voltages be determined quickly and easily. It is useful, therefore, to provide a means of varying the working anode voltage over a wide range, and for observing, at the same time, at what ranges of voltage any negative resistance or oscillatory effects are produced. Apparatus which has been used for this purpose is described in this paper.

For certain purposes the author needed measurements of this kind over a voltage range from about 80 kv down to zero. The anode current of the valves* being investigated was of the order of about 0.25 to 0.5 ampere.

The Problem

It was impractical to carry out these measurements by plotting the characteristics of the valve with a steady source of voltage. The power dissipation at, for instance, 50,000 volts and 0.25 ampere electron beam current, would destroy the valve structures long before any current and voltage readings could be made.

* British terminology for vacuum tube.

Indeed, a valve used for physics investigations is seldom capable of dissipating more than a small fraction of this power, particularly if it is dismountable for the purpose of changing the conditions of the experiment. It was required, therefore, to reduce the dissipation (during the time the characteristic was being drawn) by a factor of the order of 1,000.

Ordinary cathode-ray oscilloscope methods of drawing valve characteristics, which use an approximately sinusoidal a-c voltage as the measuring potential, tend to reduce the peak dissipation, but not to anything like the extent required.

One way of overcoming this difficulty is to charge a condenser to the maximum test voltage and to discharge it through the valve and photograph the resulting voltage-current oscillogram produced by a suitably-connected oscillograph. This photographic process was, however, far too slow for the urgent war-time program the author had in hand.

The Solution

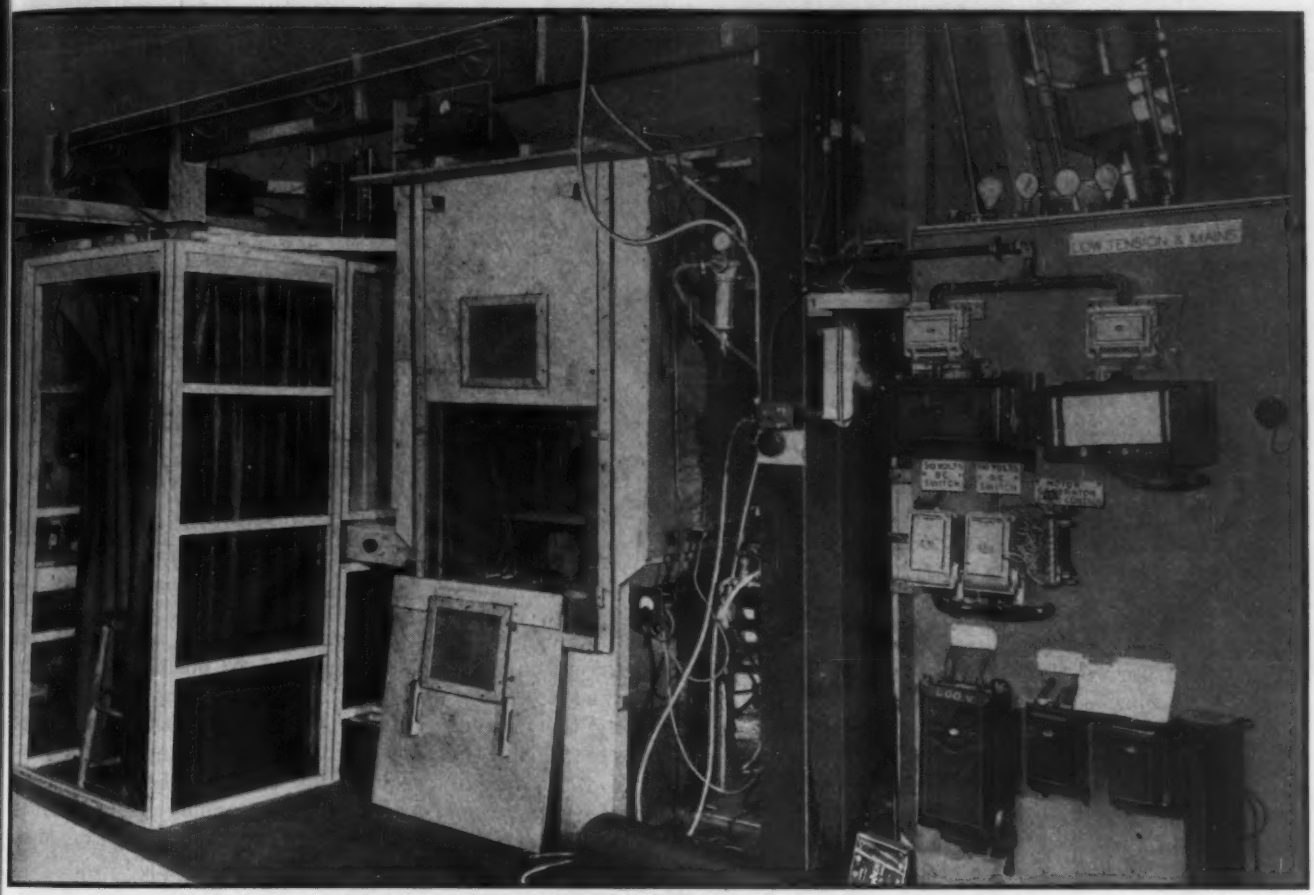
It was decided to provide a series of widely-spaced impulses, each of short duration, instead of a single pulse. The speed of the pulses would have to be just fast enough for visual observations to be made successfully on an oscilloscope.

An impulse generator of the type originally developed by Marx was used to produce a train of voltage impulses, and these were applied to the valve. These voltages and the currents to the valve were fed simultaneously to the appropriate deflecting plates of a two-beam cathode-ray oscilloscope.

It was unnecessary to use a pulse

HIGH-POWER TUBES

A method of obtaining characteristic curves of high-power tubes by applying single high-voltage impulses at widely spaced time intervals and reading values for the curves on the screen of a two-beam cathode-ray oscilloscope tube. Optimum anode kilovoltages up to 80 kv for transit time oscillator tubes are thus readily determined



Complete equipment for determining optimum anode voltages of high-power oscillator tubes. At the left is the cloth-enclosed oscilloscope viewing cabinet. Next to it is the chamber for the tube under test, with an x-ray-proof window for observation. The power control panel is at the right, with the impulse generator just visible above it

rate so high as to give (by the persistence-of-vision effect) a continuously visible trace. Instead, the impulse generator was finally arranged to give only about two pulses per second each of which lasted a few milliseconds. The resulting strokes of the spot across a graduated screen could readily be observed. In practice, an operator watched the trace and called out the readings at each ordinate of anode voltage to someone else who tabulated them. The tabulated figures were then plotted.

The horizontal deflection plates are normally both connected to the high-voltage bus through a suitable attenuator. The two beams of the oscilloscope are moved simultaneously in the horizontal or x direction at a rate proportional to the instantaneous value of the anode voltage.

The anode current of the valve being investigated is caused to deflect one of the two beams in the vertical direction. This beam therefore traces out the anode characteristic of the valve.

Use of Probe Electrode to Investigate Transit Times

A probe electrode is provided in the valve in such a position that,

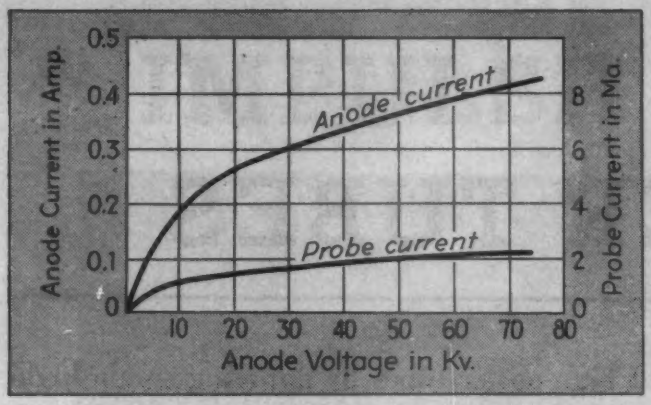


FIG. 1—Characteristic curves obtained with the impulse generator and cathode ray oscilloscope for a tube corresponding to an ordinary diode

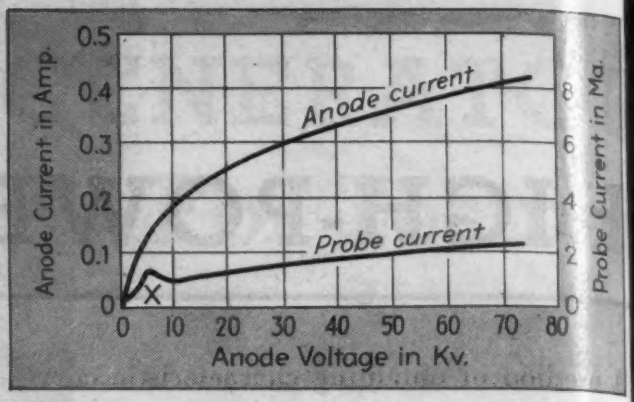


FIG. 2—Characteristic curves for the same tube as in Fig. 1 but operating under different conditions. The peak at *X* indicates the presence of oscillation over this range of anode voltage

FIG. 3—Electrode arrangement for producing and measuring the shape of an electron beam. The copper tube and the plugs P_1 and P_2 are at a positive potential with respect to the cathode and shield. Beam width and direction may be changed by moving the plugs and observing the resulting values of current intercepted

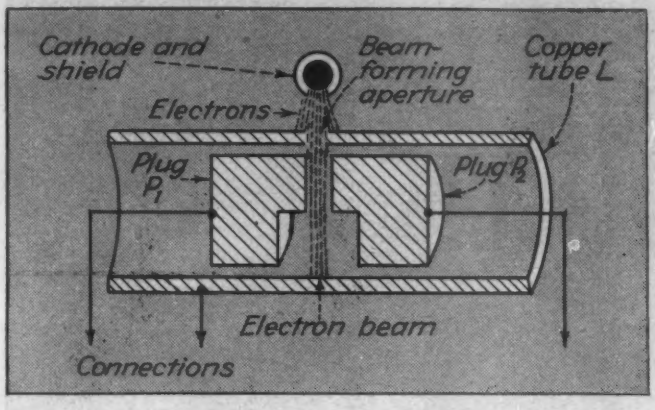
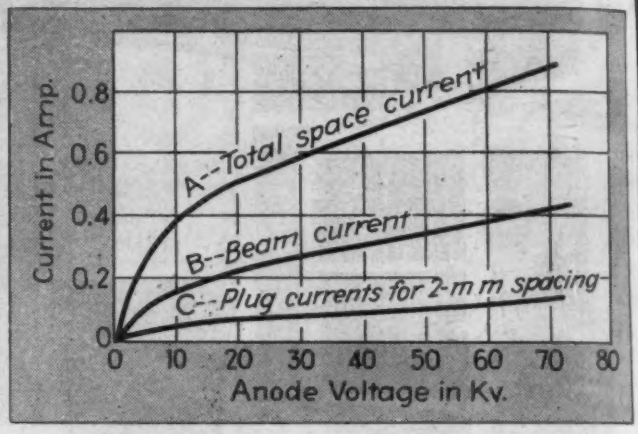


FIG. 4—Characteristic curves obtained from the apparatus illustrated in Fig. 3 when the plugs are touching (*A* and *B*) and when they are separated (*C*)



when the valve oscillates, the current picked up by this probe will change. This probe current is led to the other set of vertical or *y* deflection plates of the oscilloscope. The corresponding beam therefore traces the anode voltage-probe current characteristics of the valve.

Characteristics of a special type of valve are shown in Fig. 1. The anode current and the probe current curves are smooth. They correspond to those of any ordinary diode having a cathode structure of a particular type then employed. The conditions in the valve may be altered in such a way that oscillations are produced over a range of transit times corresponding to the order of 4000 to 10,000 volts.

The probe electrode is so arranged that, when oscillations are produced, the current to it is greater than is otherwise the case. The range of anode voltage over which the oscillations then occur is shown very clearly in the probe current curve of Fig. 2 by the peak marked *X*.

Instead of employing the current from a probe electrode to indicate the presence of oscillations, the output from a suitably connected crystal detector or the like may be employed. The pulses of rectified current are then applied to the appropriate plates of the oscilloscope.

For the investigation of transit time effects, it is usually convenient to use a valve structure which can be demounted and altered without substantially affecting the cathode characteristics. For this reason, a pure tungsten filament was employed. It is also desirable that the beam of electrons employed in the experiment does not change its shape appreciably with anode voltage. This result cannot be achieved by employing the usual magnetic or electrostatic beam-forming lenses; it is attainable by using instead a positive electrode with an aperture in the front of the cathode, and applying the anode voltage to this electrode and to the subsequent electrodes of the valve. This arrangement is analogous to the ordinary pin-hole camera. The beam is the same shape at all anode voltages.

Method of Checking Beam Shape

A valve structure for the purpose of observing the shape and focus of the beam at all anode voltages to be investigated is shown diagrammatically in Fig. 3. A copper tube *L* is provided, the axis of which is transverse to the direction of the beam. The beam passes through an aperture in the side of the tube. Plug electrodes P_1 and P_2 are arranged to slide in and out of the ends of the tube as shown, and the currents to them are recorded by the oscilloscope.

Curves *A* and *B* in Fig. 4 show ace and beam currents respectively r the condition when P_1 and P_2 are ought together to measure the total rrent produced in the beam. Curve shows the current to the plugs hen they are each 1 mm out from e center-line of the electron beam. he curves for the two plugs are here entical and superposed, indicating at the beam in this particular case as a good one, quite symmetrical, d with a reasonable ratio between e total emission from the filament d the beam current passing rough the aperture.

The current intercepted by the ugs may be plotted in terms of the tal beam current and the distance the plug from the center-line of e beam. If this curve is graphi- lly differentiated, the result will be curve of current density of the am, as shown in Fig. 5.

Details of Apparatus

The oscilloscope tube is a two- am Cossor type 339. It is used with witch gear whereby the plates may e connected directly to the input rminals without the intervention amplifiers. A time base is also pro- ded to time and record the pulse hape when desired.

The complete circuit, including the mpulse generator, the tube under st and the oscilloscope, is shown in ig. 6. With the circuit constants pecified here, the pulse duration is the order of a few milliseconds nd the pulse rate about two per sec- nd. The average power dissipation thus reduced to the desired order. A typical record obtained with this arrangement is shown in Fig. 7.

Condensers in the impulse generator may be disconnected when necessary, and the number in use reduced, for the purpose of varying the range of voltage available. The Variac autotransformer is employed to vary and adjust the spark rate.

Theory of the Impulse Generator

When the condensers are charged, the bottom spark gap (which is narrower than the others) breaks down to the grounded end of the second condenser (marked *B* in Fig. 6). The top plates of this condenser then reach twice the charging voltage, which causes the second spark gap from the bottom to break down. The top plates of the third condenser (*C*) then reach three times the charging voltage, and the third gap breaks down,—and so on.

This successive and very rapid action of the gaps has the effect of connecting all the condensers in series. The circuit is arranged to discharge them all (when so connected) through the external circuit, via the discharge gap and bus bar, in a time much shorter than the charging time of the individual charging circuits of each condenser. For instance, the condensers may take about half a second to charge, but the time constant of the external circuit is arranged to be such that the discharge time is about two milliseconds. Therefore, during the very short period of discharge, the charging and grounding resistances have little effect on the voltage across each condenser, and the impulse generator, as a whole, acts as a number of condensers in series being discharged through the external circuit through the main spark gap.

In practice, the voltage obtained is not quite equal to n times the charging voltage (where n = the number of condensers). This is partly because all the condensers are not charged quite equally at the moment of discharge. Furthermore, the

(*Continued on page* 326)

FIG. 5 (right)—Variation of current density in electron beam with spacing between plugs. The data was obtained with the valve arrangement of Fig. 3

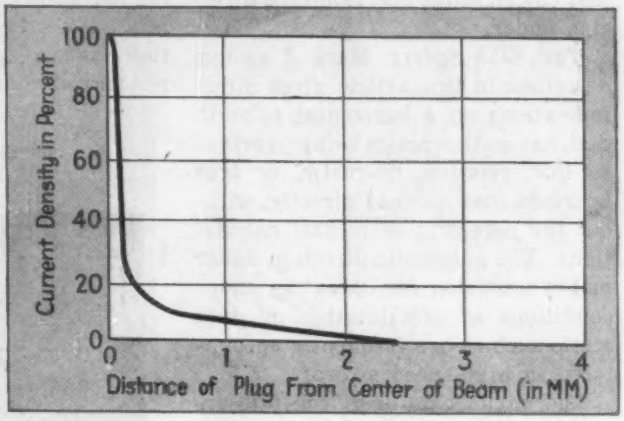
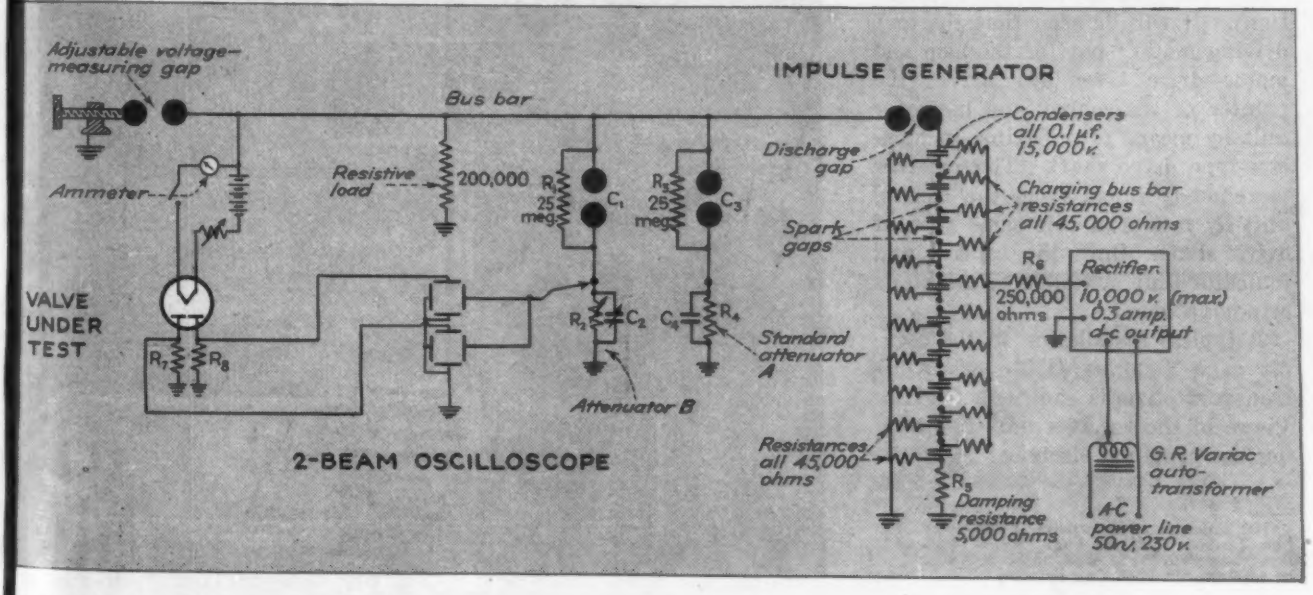


FIG. 6 (below)—Circuit arrangement of an impulse generator and cathode - ray oscilloscope for measuring valve characteristics by short-duration high-voltage pulses



VISUAL DIRECTION FI

Description and circuit of the RCA-Sperry Mark I automatic direction finder for aircra designed to indicate directly and without 180-deg. ambiguity the direction to whatever rad station is tuned in by the pilot. Four possible types of operation are considered

THE MAIN FIELDS of use for aircraft automatic direction finders are commercial air transport service and military service, where continuous and automatic nonambiguous bearing indications with simultaneous headphone reception are required. Commercial equipment meeting the requirements of these services is ordinarily designed to permit use as (1) a receiver, (2) a self-orienting automatic direction finder, and (3) an aural-null loop-type direction finder.

The RCA-Sperry Mark I system described in this article gives direct indications on a horizontal azimuth dial, navigation scales being provided so that relative, magnetic, or true bearings may be read directly, without the necessity of mental calculations. The automatic direction finder makes provision for operation under conditions of precipitation or dust static such as are frequently encountered in high-speed aircraft.

The various units in the Mark I equipment are shown in Fig. 11, which illustrates the interconnections. It will be seen that the loop driving motor (part of the loop and motor drive assembly) drives the pointer of the control and indicator unit by means of a flexible tachometer-type drive shaft. The receiver is remotely tuned from the control unit by means of this same type of drive shaft. Only the control and indicator unit is visible to the pilots or navigator.

A typical installation in the cockpit of a Douglas DST (or DC-3) transport plane is shown in Fig. 12. Views of the receiver unit (containing the principal electrical circuits), the control and indicator unit, and the loop assembly are shown in Fig. 13 to 15.

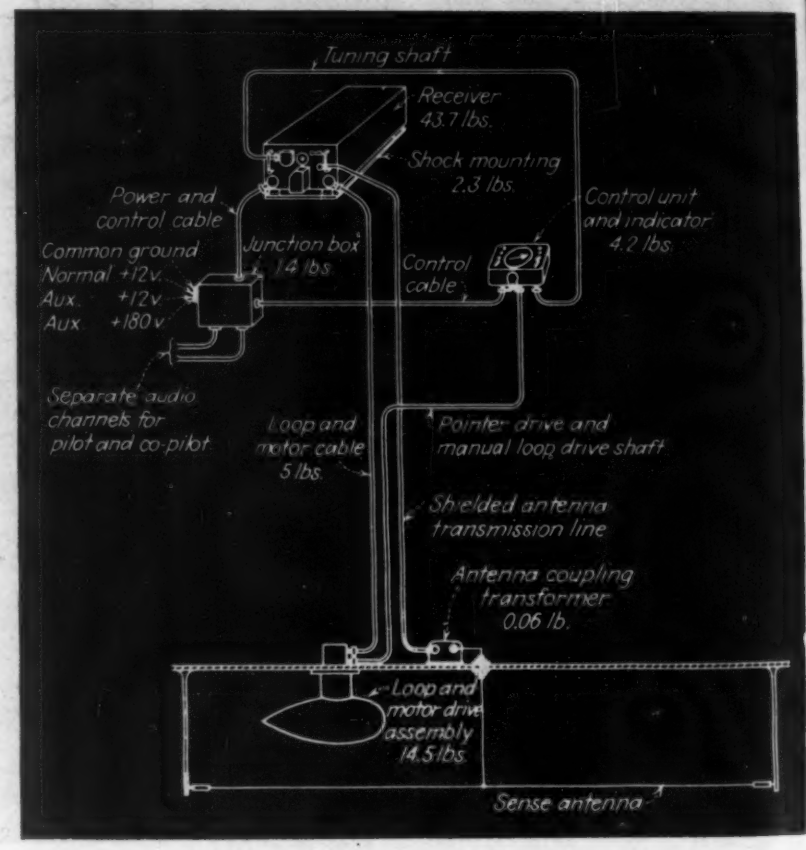
When the equipment is used as an automatic direction finder, it is only necessary to tune in the desired station. The azimuth indicating pointer on the control unit then revolves and comes to rest with the arrow pointing in the actual direction of the station. The relative bearing or the magnetic bearing may then be read off the proper scale directly. There is no 180-deg. ambiguity, and direction finder operation is entirely independent of volume control settings.

The schematic diagram of Fig. gives details of circuit operati Four types of operation may be c sidered: (1) Reception (nondir tional); (2) Automatic directi finding (with nondirectional se antenna); (3) Automatic directi finding (anti-static); (4) Aural n direction finding.

Complete Circuit Diagram

Under conditions of reception wi the conventional nondirectional or antenna, the apparatus is a high selective superheterodyne receiv suitable for operation in the aircra

FIG. 11—Interconnections between the various units of the RCA-Sperry Mark I automatic visual direction finder for aircraft



*This series of three articles is condensed from Chapter VI of the book "Radio Direction Finders" by D. S. Bond, to be published by McGraw-Hill Book Co., Inc.

FINDERS . . . Part 11

By DONALD S. BOND*
Radio Corporation of America, Camden, N. J.

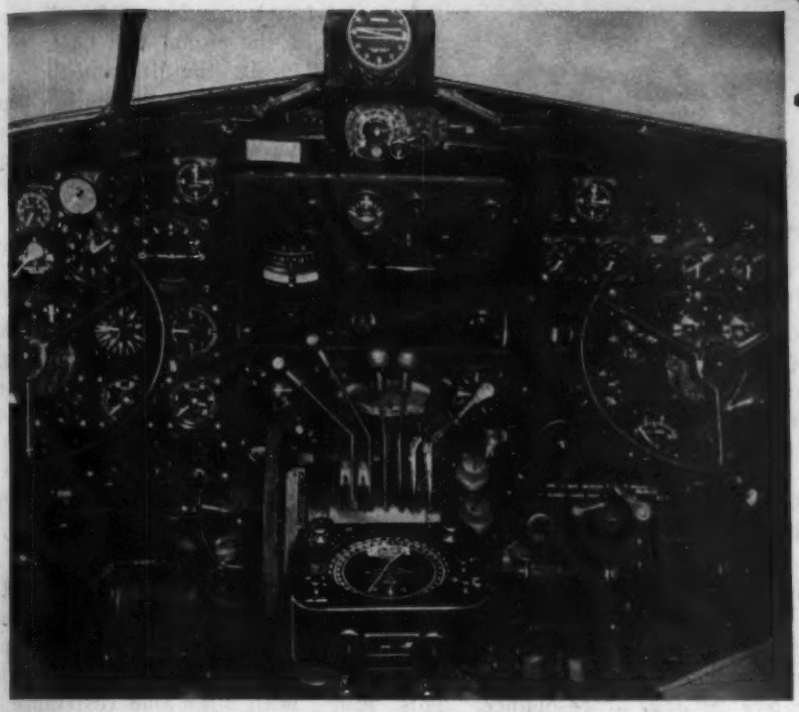


FIG. 12—The control and indicator unit of the Mark I system appears at the bottom center in this view of the cockpit of a Douglas DC-3 transport plane

adio range and marine band (*X*: 200-500 kc) and in the broadcast band (*A*: 550-1500 kc). Operation is described for the *X* band only, except where that for the *A* band is considerably different.

In operation as an automatic direction finder with a nondirectional sense antenna, the input from the loop (referred to as the null loop) is amplified and put through a balanced modulator, which suppresses the carrier and provides double sidebands. The latter result from the presence of a 100-cps modulating voltage obtained from the power source serving the a-c loop drive motor. The sidebands are combined with the input carrier from the sense or nondirectional antenna, and the resultant is fed into the superheterodyne receiver circuits.

Thus the signal passing through the receiver has impressed on it the 100-cycle amplitude variation due to the sidebands. As the loop is rotated from one side of the null to the other, the 100-cycle envelope reverses in phase. The signal is detected and amplified to furnish audio headphone output of speech components present on the original carrier, while the 100-cycle component obtained from the local modulator is filtered out, amplified, and used to actuate a motor control circuit. This, however, is not an audio amplifier but a thyratron-controlled circuit to accomplish the same result at much higher power efficiency.

An alternate mode of operation is available for the case when rain, snow, or dust static renders an unshielded antenna completely unusable. The shielded null loop is still capable of functioning, but there is substituted an auxiliary or sense loop in place of the sense antenna. Automatic operation is retained, but the freedom from 180-deg. ambiguity is sacrificed under this one condition.

Lastly, aural null operation in conventional fashion is possible. This

THIS SERIES INCLUDES:

PART I—Principles of automatic and right-left types of visual direction finders. Nov. 1943 ELECTRONICS.

PART II—RCA-Sperry Mark I automatic direction finder. In this issue.

PART III—Bendix Model MN-31 automatic direction finder. To come.

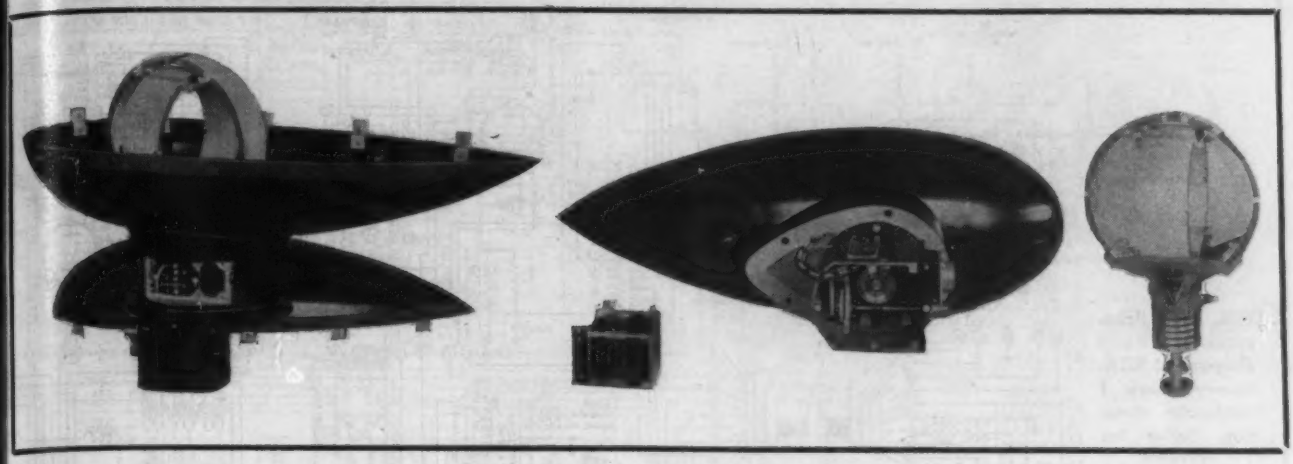


FIG. 15—Views of Mark I loop assembly

to have small effect at audio frequencies, and it constitutes an i-f filter. The portion of the amplified a-f voltage across R_{68} is fed into the phone audio amplifier through coupling capacitor C_{66}. R_{71} and C_{66} make up an i-f and a-f plate filter for V_7. To prevent a-f distortion, screen voltage for V_7 is obtained separately from the B-supply through the high resistance R_{69}, bypassed by C_{43}, with a bleeder to ground R_{72}.

Automatic Volume Control. The action of the automatic volume control may next be considered. At all times the grid of V_7 has avc voltage. It is obtained from the d-c component across R_{30}, and is reduced in the required proportions by voltage divider R_{41} and R_{38}, point A of the second i-f transformer being returned to the negative side of cathode bias resistor R_{34}. Thus the avc action on the grid of V_7 is practically independent of the setting of the manual sensitivity control (X band). The circuit controls the gain of V_7 twice—for i-f and for a-f signals—and results in exceptionally flat avc action where the latter is employed.

The avc diode D_2 is fed through capacitor C_{34} from D_1. Rectification of the i-f signal causes a direct voltage to appear across R_{31}, provided the peak i-f voltage exceeds the voltage-delay bias appearing across R_{24} and R_{29}. The rectified direct voltage is filtered by the common avc line elements R_{32} and C_{40} and by individual stage filters including series elements R_{17}, R_{21}, and R_{25} for V_4, V_5, and V_6 respectively. The voltage-delay prevents action of the avc until a certain antenna input signal has been attained.

The tuning meter is in the common cathode return of tubes V_4, V_6, and V_7. When avc is on, a signal causes these tubes to be biased considerably more negative, so that the plate (and hence cathode) current is reduced, and this indication is given on the meter.

Manual Sensitivity Control. At all times, the cathode bias resistor R_{28} of tube V_6 returns to ground. However, the corresponding resistors R_{18} of V_4 and R_{26} of V_6 return through sensitivity control R_{53} to ground. R_{39} and R_{42} constitute a voltage divider to raise the cathode bias higher above ground as the sensitivity control is reduced (as R_{53} is increased). Automatic volume control continues to be developed under these conditions (X band reception or X-band aural null direction finder operation) but its action is overridden by the manual control, so that the automatic action serves only to prevent overload and course reversal. For this reason, it will be referred to as "AVC Off." AVC switching is accomplished by switch S_2.

Phone Output Amplifier. The a-f signal fed into the phone audio amplifier through C_{66} passes through the audio compensator circuit composed of reactor L_{34} and capacitor C_{51}. This is tuned to boost the higher audio frequencies necessary for intelligibility (1,500-2,000 cps) without affecting the 3-kc adjacent channel attenuation of the direction finder system. (The radio range transmitters of U. S. civil airways have frequency assignments based on a 3-kilocycle channel separation.) Audio then feeds into the grid of tetrode phone output tube V_8, the plate of which couples to balanced dual-channel output transformer assembly T_1. This hybrid coil system feeds audio from V_8 into both phone channels (terminals 3-4 and 5-6 on T_1), but prevents signal fed externally into one channel from being heard in the other channel. This allows parallel operation of a number of similar receivers, each designed for two phone circuits.

The two pairs of output terminals may be considered as conjugate terminals (battery and detector) of a Wheatstone bridge, with the signal from V_8 fed unsymmetrically into one arm. Reactor L_{40} constitutes a low-frequency balancer, while R_{69} and R_{70} make up two arms of the bridge.

Automatic Direction Finder Operation (Nondirectional Sense Antenna)

Loop Amplifier Channel. The receiver channel functions in the same manner as described above under Nondirectional Reception. In addition to a signal from the nondirectional antenna, a signal from the null loop L_1 is fed through the entire loop channel to primary L_{10} of the antenna transformer. The loop connects through the shielded transmission line of the loop cable to primary L_{20} of the loop input coupling transformer. Secondary L_{21} of this unit is tuned by the first section of gang capacitor C_1. The high-frequency trimmer is C_{18}, and L_{21} is adjustable in inductance. The transformer connects to the grid of tube V_1.

The pentode section of this tube constitutes an amplifier and r-f phase shifter. In order to cause the signal from loop L_1 to be in phase (or 180 deg. out of phase) with the signal from the antenna at the point where these inputs mix at the grid of V_4, a phase shift of approximately 90 deg. must be introduced in one channel because the loop terminal voltage is 90 deg. out of phase with that

FIG. 13—Receiver unit of Mark I automatic direction finder

may be used in emergencies for direction finding in case of failure of any portion of the automatic system; or may be used for reception, with the loop at maximum, during periods of precipitation static.

Nondirectional Reception

R-F circuits. The signal from the nondirectional antenna is fed into the antenna coupling transformer (L_8 — L_4 at upper left in Fig. 16) and from there through the low-capacitance transmission line to the low-impedance side of antenna transformer secondary winding L_{11} in *R-F Comp.* No. 2 after passing through switches S_9 and S_{9A}, relay RE_1, antenna blocking capacitor C_{35} and band switch S_4. Section C_2 of the gang capacitor tunes this circuit to resonance.

Adjustable capacitor C_{10} is shunted across C_2 on this band for trimming purposes at the high-frequency alignment point (450 kc). The inductance of L_{11} is adjustable by means of a magnetite core for alignment at the low-frequency point (220 kc). Capacitor C_8 (below V_2) shunts the antenna transmission line on the *X* band only. Independent adjustments are provided on the two frequency bands, so that alignment adjustments in one band will have no effect upon the other. Consequently, either band may be aligned first. Primary windings L_9 and L_{10} are inoperative for nondirectional reception, L_9 being open-circuited by relay RE_1, and L_{10} connecting to tubes V_2 and V_3, which are blocked by having the B-supply cut off by S_{9A}.

The grid of tube V_4 in *R-F Comp.* No. 3 is connected to a tap on L_{11}. The circuit design permits high signal-noise ratio with good image attenuation. No band switching is required in the antenna coupling transformer unit. R-F phase shift through the antenna input system is approximately 90 deg. at resonance. This characteristic becomes of importance when the antenna is used fo "sens in direction finder operation.

From the plate of V_4, the signal fed through the remaining porti of the r-f amplifier. A detailed e amination of the circuit disclos that precautions have been taken realize high r-f selectivity and sp rious response attenuation.

I-F Amplifier. The signal at t intermediate frequency is f through an i-f amplifier which i cludes transformers IF_1 and I This portion of the amplifier is co ventional.

Since V_7 serves simultaneously an i-f and an a-f amplifier, the pro ress of the signal will be traced detail. At the intermediate fr quency, C_{36} by-passes the low-impe ance side of secondary L_{25} to grou and to cathode via C_{41}. The i-f sign consequently appears on primary of the third i-f transformer, IF whose low-impedance side is sim larly returned to ground through C Secondary L_{26} feeds diode plate D_1 V_7 directly. The load across whi audio-frequency voltage is develope is R_{30}. To prevent audio distortio R_{30} returns directly to the cathod C_{36}, R_{32}, and the series combinati of C_{37} and C_{36} serve as an i-f filter.

First Phone A-F Amplifier. Th audio voltage on R_{30} feeds through C to the high side of grid resistor R At audio frequencies this point effectively at grid potential, L_{25} hav ing low and C_{36} having high impe ance. V_7 then serves as an a-f am plifier with plate load resistance R The impedance of C_{34} is high enoug

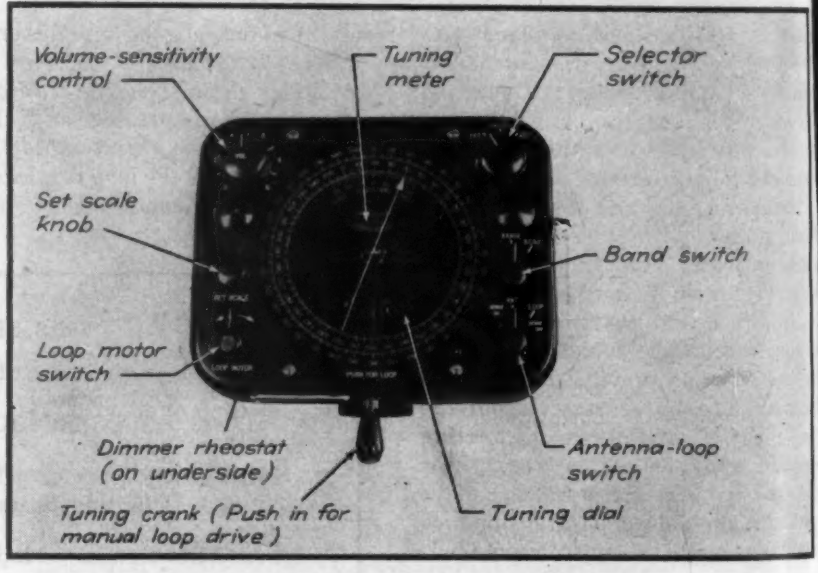
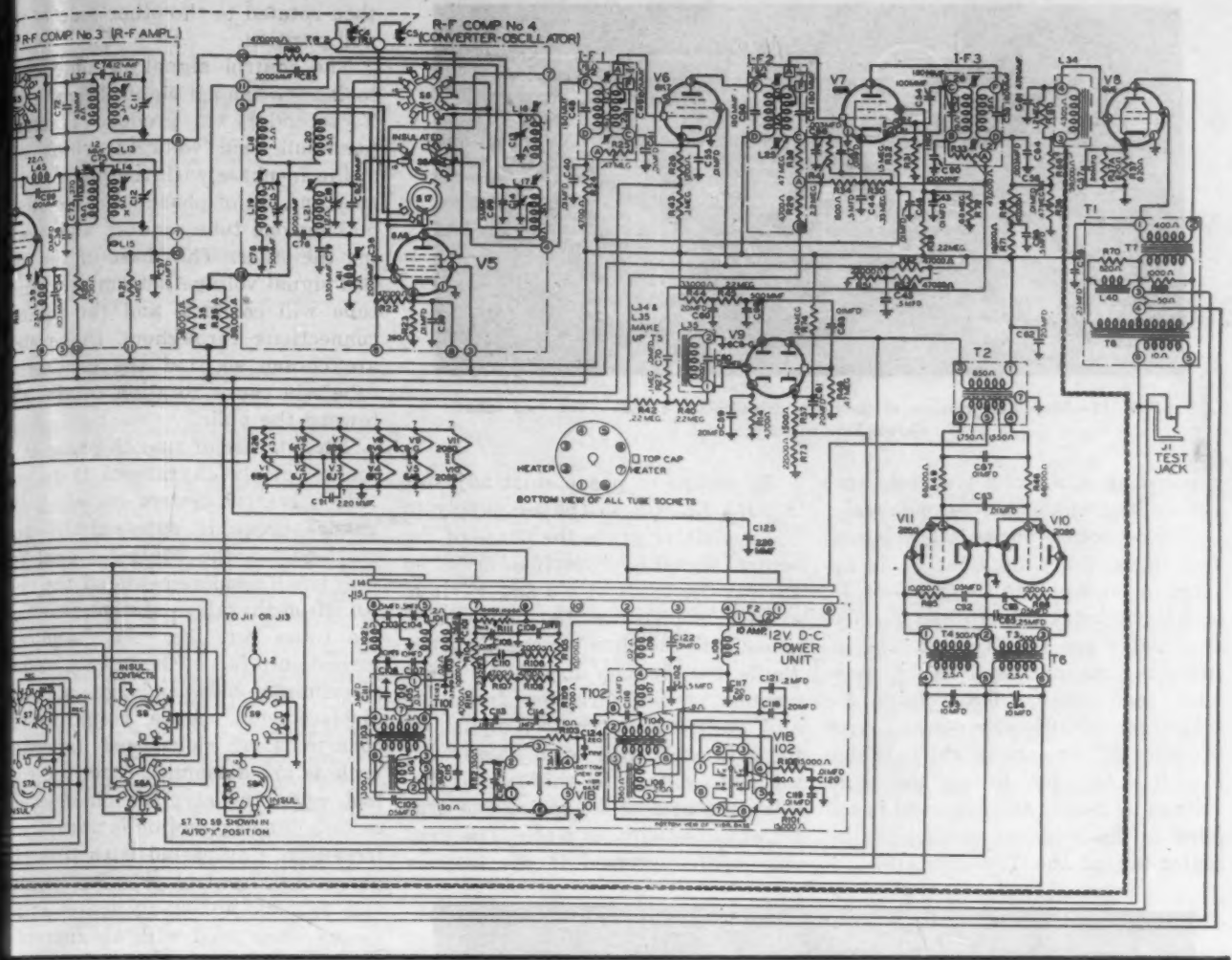


FIG. 14—Close-up view of control and indicator unit



ndary A_1 of one transformer, the mpedance looking into primary B_1 s also low, and winding W_1 is effectively connected across the a-c power upply. At the same time, if V_{11} exhibits high impedance, the load cross secondary A_2 will be solely ue to capacitor C_{66}. Due to the high mpedance ratio of the transformer, he reflected impedance in B_2 appears s a large capacitance in series with winding W_2 across the a-c supply. This capacitance is the same value as would be chosen to give the approximate 90-deg. phase displacement required for a two-phase capacitor-type motor. The conditions of 90-deg. phase shift between voltages applied to the motor windings are those for maximum torque in one direction.

When V_{10} is made high in plate impedance while V_{11} is low, the roles of T_3 and T_4 are interchanged. W_2 is connected across the a-c line while W_1 is in series with the large capacitance due to the transfer of C_{66} to secondary A_1. The phase of the excitation to W_2 is now —90 deg. instead of +90 deg., and the motor rotates in the opposite direction.

Any types of variable impedances might be considered for V_{10} and V_{11}. In the actual circuit used in the Mark I direction finder, these are grid-controlled gaseous tetrodes, commonly known as thyratrons. They are characterized by low arc drop or low internal resistance when conducting. The arc drop is of the order of 10 volts and is independent of the plate current, so that by using high plate voltage the voltage drop in the tube may be neglected.

The plate current is limited only by the plate load impedance. With the grid kept negative the tube does not conduct, and the plate impedance is very high. But as the grid voltage is made less negative, the point is reached where the tube conducts or fires. The grid then no longer has any control regardless of grid voltage, and the arc can be extinguished only by reducing the applied plate voltage below the internal arc drop voltage. With an a-c supply for the plate, this occurs in every cycle, and thus the tube can be started and stopped by making the grid less or more negative respectively.

It is to be noted that the tubes can conduct only on the positive half cycles. Due to the inductance of the motor windings and transformers, the half-cycle pulses are smoothed into fair sine wave form. If the grid voltages are d.c., the average plate currents may be varied continuously over a considerable range, and hence the plate impedances may be made low or high at will.

Simplified Motor Circuit. The actual circuit with various filter components omitted is shown in Fig. 17. The voltage difference across primaries B_1 and B_2 due to the applied a-c voltage is stepped up to 300-350 volts and applied to the plates of V_{10} and V_{11}. To the tubes, each transformer is a source of a-c plate voltage. To the motor, each tube when

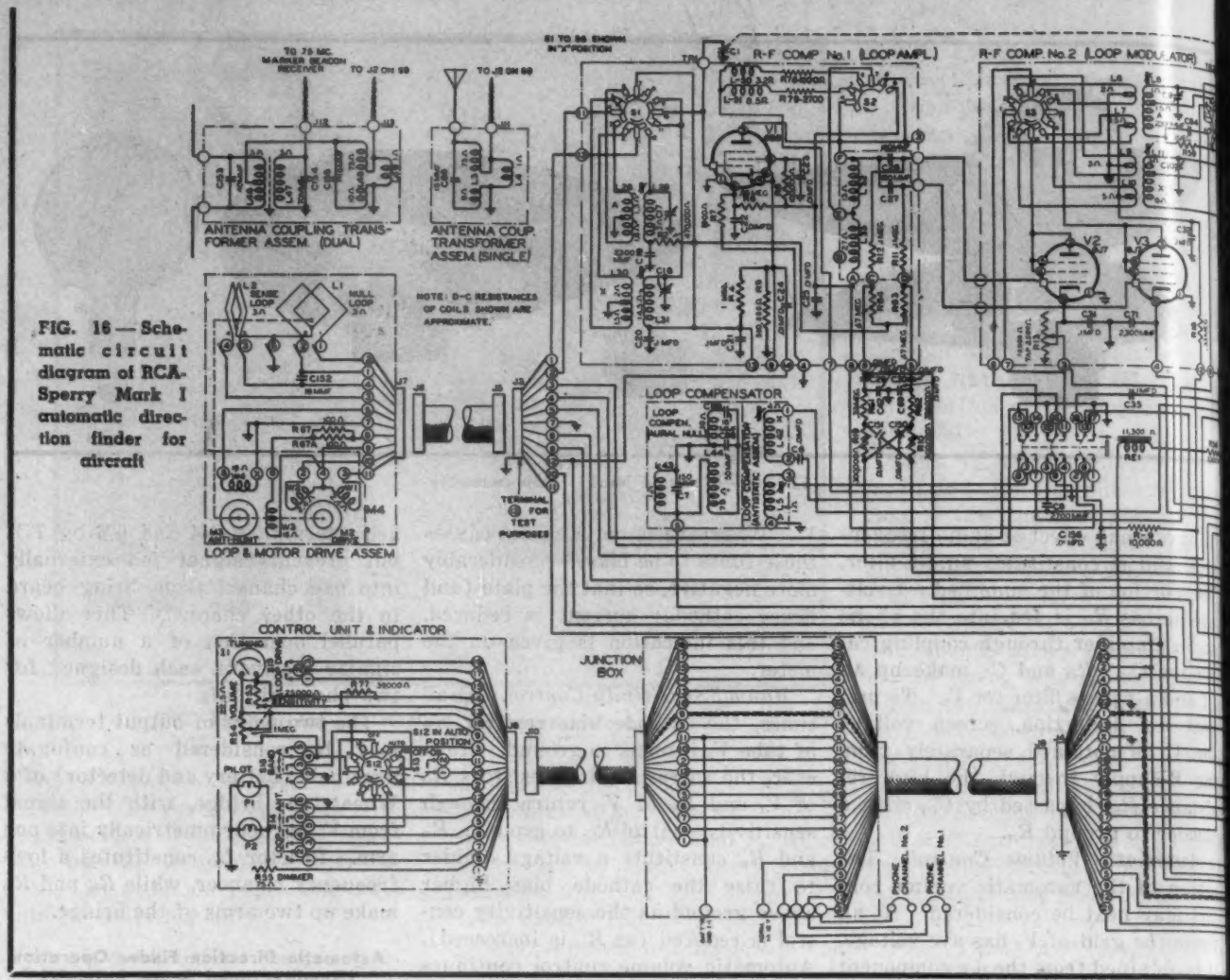

R-F COMP. No.1 (LOOP AMPL.)
R-F COMP. No.2 (LOOP MODULATOR)
ANTENNA COUPLING TRANSFORMER ASSEM. (DUAL)
ANTENNA COUP. TRANSFORMER ASSEM. (SINGLE)
LOOP & MOTOR DRIVE ASSEM
LOOP COMPENSATOR
CONTROL UNIT & INDICATOR
JUNCTION BOX

FIG. 16 — Schematic circuit diagram of RCA-Sperry Mark I automatic direction finder for aircraft

from the nondirectional antenna. The shift is accomplished by the plate load L_{20} of V_1, which is resonated by its own distributed capacitance at a frequency below the tuning band, and hence constitutes approximately a pure reactive load throughout the band. The function of the diodes in V_1 is explained in the discussion of the loop overload circuit below.

Tubes V_2 and V_3 constitute a balanced modulator of the type previously analyzed. The control grids are excited in parallel by the r-f carrier from V_1 through r-f coupling capacitors C_{28} and C_{27}. Simultaneously these grids are fed in push-pull at an audio frequency of 100 cps from the a-c vibrator supply through a filter and phase-shifting network. The plates of triodes V_2 and V_3 are connected in push-pull to primary L_{10} of the antenna transformer. Since this transformer will not transmit audio frequencies appreciably, the net result is that there appears from the loop channel at the grid of V_4 a carrier-suppressed double sideband signal, the sidebands corresponding to the 100-cps modulating frequency. This is combined with the carrier from the antenna in L_{11}.

Motor Control Circuit. The audio output is obtained from diode load resistor R_{20} and fed through C_{70} to the input of the motor control amplifier. It consists of the 100-cps component introduced by the balanced modulator V_2 and V_3 and all speech and other audio components present on the received carrier. Filter L_{35} and C_{80}, tuned to 100 cps, attenuates the speech components and passes the 100-cps modulating frequency. This latter is termed the control signal.

The control signal then feeds to the first triode section of V_9, serving as a resistance-capacitance coupled amplifier and driving the second triode section. The latter is transformer coupled by T_2 to the push-pull grids of V_{10} and V_{11}. Resistor R_{22} is short-circuited by switch S_{3A} to permit normal bias to be applied to the cathode of the second section of V_4 for automatic operation.

Drive motor M_2 is a two-phase two-pole induction motor operating in the manner shown in Fig. 17. The two-phase motor windings are W_1 and W_2; T_3 and T_4 are the motor control transformers, and C_{66} is the capacitor which provides the quadrature component required for motor operation. The a-c power is applied to the junction of the primaries of T_3 and T_4 at terminal 5 and to the common of the two motor windings. T_3 and T_4 are connected as shown so that secondary terminals 1 and 3 are of the same polarity. When the tubes are inoperative, C_{66} is consequently across points of no voltage difference. Under this same condition the primaries of the transformers appear as high impedances due to the open secondaries, and no power is supplied to the motor.

If tube V_{10} is made operative and presents low impedance across sec-

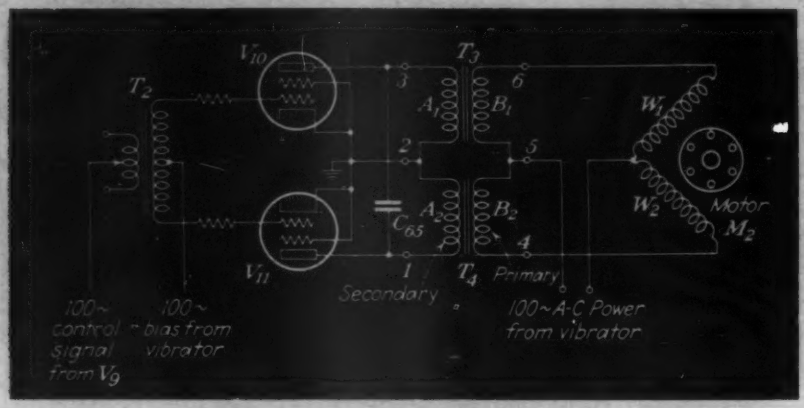


FIG. 17—Simplified version of the loop drive motor circuit. The two tubes shown here are thyratrons

conducting acts like a low resistance across its transformer secondary.

The reversible-phase 100-cycle control signal from amplifier V_9 is applied in push-pull to the grids of V_{10} and V_{11} by input transformer T_3. The two plates are fed from A_1 and A_2 in such a manner as to be in phase with each other. Low-voltage a-c bias from the 100-cycle power source is adjusted by phase shift bridge R_{105}, R_{107}, C_{110}, R_{108} to lag the plate voltage by nearly 180 deg., and is applied to the grids in parallel by the center-tap of the T_3 secondary.

By means of phase shift adjuster R_{10}, R_{12}, C_{130}, C_{131} in the a-c supply to the modulator grids, the phase of the control signal is properly adjusted so that at the grids of V_{10} and V_{11} it is exactly in phase or 180 deg. out of phase with the plate voltage. In other words, for the loop displaced a small amount in one direction from the null position, the control signal on the grid of V_{10} will be in phase with the plate voltage on this same tube, while the grid of V_{11} is fed 180 deg. out of phase with its plate. The grid phases are reversed if the loop is

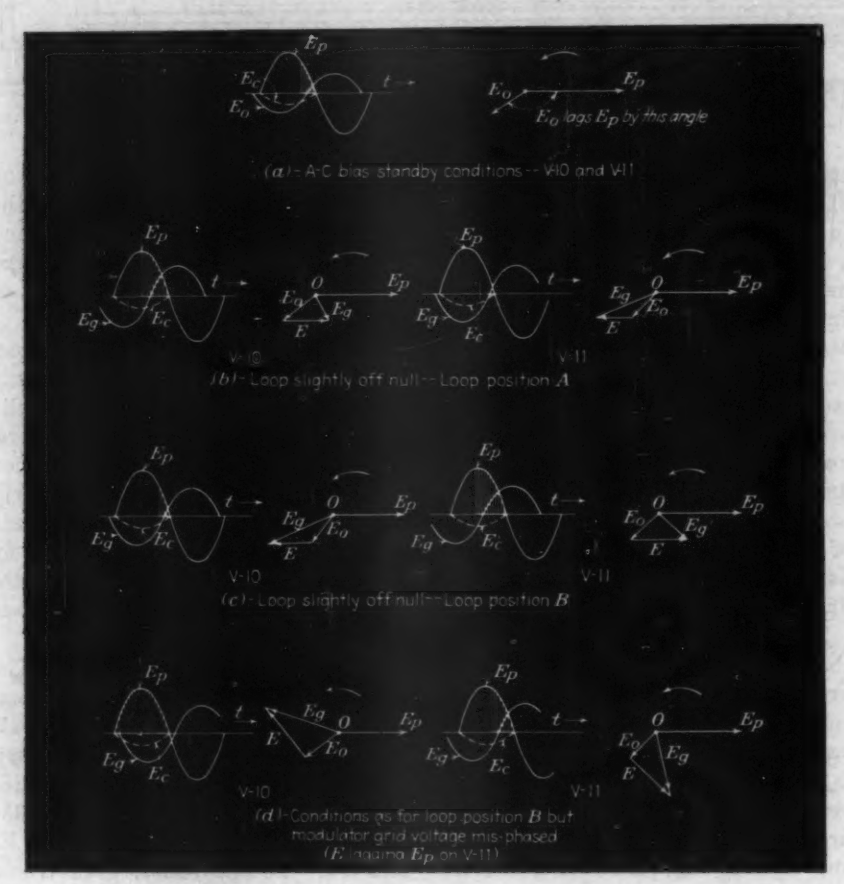


FIG. 18—Diagrams showing the phase relations involved in phase shift control for the thyratrons of the loop drive motor circuit

then rotated to the other side of the null position.

The control signal is added vectorially to the a-c bias voltage in the T_2 secondary to produce resultant push-pull grid voltages which will swing in phase with the plate of one tube and out of phase with the other, making one tube conduct and blocking the other. The phase of the control signal voltage determines which tube will conduct, and the various connections throughout the system are chosen so that the conducting tube will cause rotation of the loop toward the null.

The purpose of smooth phase shift control of the thyratrons is to provide a control system in which the motor torque is substantially proportional to the control signal for very small displacements off the null. An off-on thyratron system, in which the tubes act like relays and are turned only full off or full on, cannot discriminate between large and small displacements. As a result, under conditions of slow-speed following such as are demanded from the control when the airplane changes direction, the loop motion is abrupt and irregular. Contrasted with this, the phase shift control provides smooth and uniform follow-up action at all speeds when used with an appropriate anti-hunt circuit as will be described below.

Phase Shift Control. Figure 18 shows the phase relations involved in phase shift control. In (*a*), E_p is the a-c voltage applied in parallel to the plates of V_{10} and V_{11}. The dotted line indicates E_c, the critical grid voltage which is the negative grid voltage that will just keep the tube from firing. The a-c bias applied in parallel to the grids and nearly in phase opposition to the plate voltage is E_0. It intersects E_c late in the positive half cycle, and therefore both tubes conduct over the remaining portion of the half cycle as shown by the shadowed area. This is the a-c bias standby condition which occurs in the absence of control signal. The amount each tube conducts is rather small, perhaps 4 to 8 ma as read on a d-c meter in each plate circuit.

In (*b*) of Fig. 18, the loop is slightly off the null. The small control signal E is in phase with the plate voltage of V_{10} and therefore is 180 deg. out of phase with the plate of V_{11} due to the push-pull grid connec-

(*Continued on page 324*)

Universal Wave Guide Chart

Four curves on a graph give directly the phase constant, phase velocity, group velocity, attenuation constant and wavelength for both rectangular and circular guides

By ARTHUR BRONWELL

Technological Institute
Northwestern University
Evanston, Ill.

IT is possible to express the properties of wave guides in such a manner that the equations are identical for all rectangular and circular guides excited in either the transverse electric (TE) or the transverse magnetic (TM) modes. This makes possible the construction of a single set of curves to represent: (1) phase constant, β, (2) wavelength in the guide, λ_g, (3) phase velocity, v_p, and (4) group velocity, v_g, at wavelengths below cut-off, as well as (5) the attenuation constant, α, above the cut-off wavelength. The curves forming part of this Reference Sheet are applicable to all modes of transverse electric and transverse magnetic waves in either hollow guides or dielectric filled guides. In deriving the equations from which the curves were plotted, it was assumed that the losses in the walls of the guide and in the dielectric were negligibly small, an approximation which is valid for hollow guides and approximately correct in the case of low-loss dielectric filled guides.

The graph shows four separate quantities plotted as ordinates against the ratio of the impressed wavelength to the cut-off wavelength, λ/λ_c, or the corresponding frequency ratio, f_c/f. To make use of the chart it will be necessary to know both λ and λ_c. For rectangular wave guides whose cross-section dimensions are a and b, the cut-off wavelength is given by

$$\lambda_c = \frac{2\pi}{\left[\left(\frac{\pi m}{a}\right)^2 + \left(\frac{\pi n}{b}\right)^2\right]^{\frac{1}{2}}} \qquad (1)$$

where m and n are integers expressing the mode of oscillation in the a and b directions.

For cylindrical wave guides of radius b, the cut-off wavelength is

$$\lambda_c = 2\pi b/kb \qquad (2)$$

where values of kb for various modes of excitation are given in the table. Knowing λ and λ_c, the other values can be found.

These equations are valid for either hollow guides or metallic guides filled with a lossless dielectric medium. The wavelengths λ and λ_c also satisfy the relationship

$$f\lambda = c/\sqrt{k} = v \qquad (3)$$

where c is the velocity of light (3×10^{10} cm per sec), k is the dielectric constant, which is unity for hollow guides, and v is the velocity of propagation in unbounded dielectric having the properties of the dielectric in the guide. For hollow guides $v = c = 3 \times 10^{10}$ cm per sec. For given guide dimensions the cut-off wavelength is the same for hollow or dielectric filled guides. However, the velocity v is smaller for dielectric guides, hence the cut-off frequency is lower. These equations will be modified somewhat if the dielectric losses are taken into consideration.

As an illustration of the use of the curves, consider the special case of a hollow rectangular wave guide having the dimensions $a = 10$ cm and $b = 12$ cm, excited in the $TE_{1,1}$ mode. We will assume that the wavelength of the impressed signal is $\lambda = 13$ cm. The cut-off wavelength then becomes

$$\lambda_c = \frac{2\pi}{\left[\left(\frac{\pi}{10}\right)^2 + \left(\frac{\pi}{12}\right)^2\right]^{\frac{1}{2}}} = 15.35 \text{ cm}$$

The ratio of impressed to cut-off wavelength is $\lambda/\lambda_c = 13/15.35 = 0.847$. From the chart we may obtain the following values:

$\lambda_g/\lambda = 1.89$ or $\lambda_g = 1.89 \times 13 = 24.6$ cm
$v_p/v = 1.89$ or $v_p = 1.89 \times 3 \times 10^{10} = 5.68 \times 10^{10}$ cm/sec*
$v_g/v = 0.525$ or $v_g = 0.525 \times 3 \times 10^{10} = 1.58 \times 10^{10}$ cm/sec
$\beta\lambda = 3.25$ or $\beta = 3.25/13 = 0.250$ radians/cm

If the impressed wavelength had been $\lambda = 20$ cm, then $\lambda/\lambda_c = 1.30$ and the wave would be attenuated in the guide. The value of $\alpha\lambda$ is then 5.1 and $\alpha = 0.255$ nepers per cm or 2.21 db per cm, since 1 neper = 8.69 db.

It should be borne in mind that the attenuation considered here is not due to power loss in the guide walls, but rather, consists of a reflection of the wave energy back to the source due to the fact that the guide dimensions are below cut-off. There is no power loss in this type of attenuation, and the attenuation constant indicates how rapidly the electric and magnetic field intensity components decrease as the wave progresses along the guide.

If the guide is of circular cross-section, with $b = 5$ cm, and excited in the $TE_{1,1}$ mode with $\lambda = 13$ cm, the cut-off wavelength is $\lambda_c = 2\pi b/kb = 2\pi \times 5/1.84 = 17.1$ cm. The ratio is then $\lambda/\lambda_c = 0.761$ and, from the chart, we have the following values:

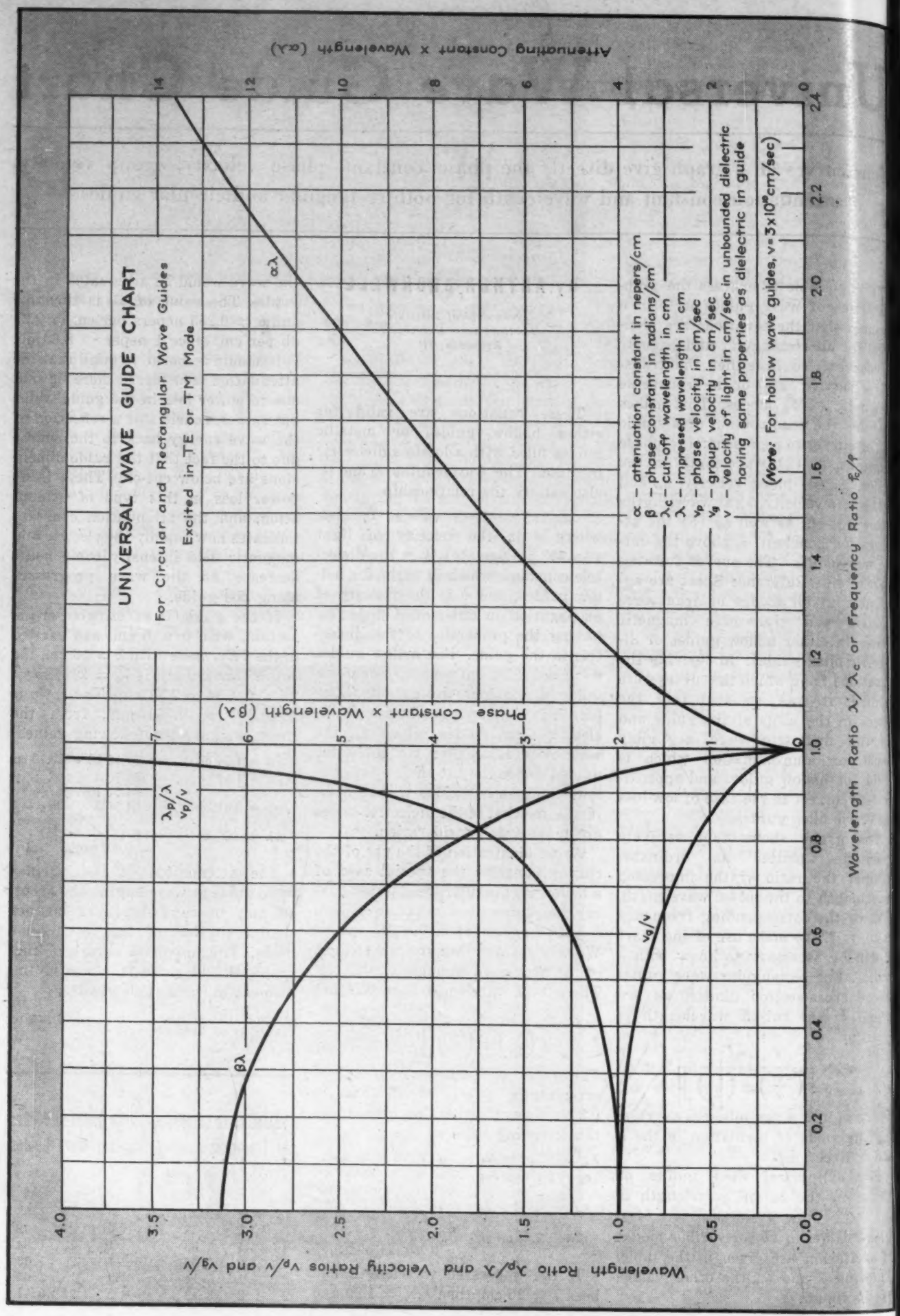
$\lambda_g/\lambda = 1.54$ or $\lambda_g = 1.54 \times 13 = 20.10$ cm
$v_p/v = 1.54$ or $v_p = 1.54 \times 3 \times 10^{10} = 4.64 \times 10^{10}$ cm/sec*
$v_g/v = 0.645$ or $v_g = 0.64 \times 3 \times 10^{10} = 1.93 \times 10^{10}$ cm/sec
$\beta\lambda = 4.0$ or $\beta = 4.0/13 = 0.307$ radians/cm

The attenuation of the circular wave guide at wavelengths above cut-off may be computed in a manner similar to that of the rectangular guide. The universal nature of this graph should make it a useful implement in wave guide studies.

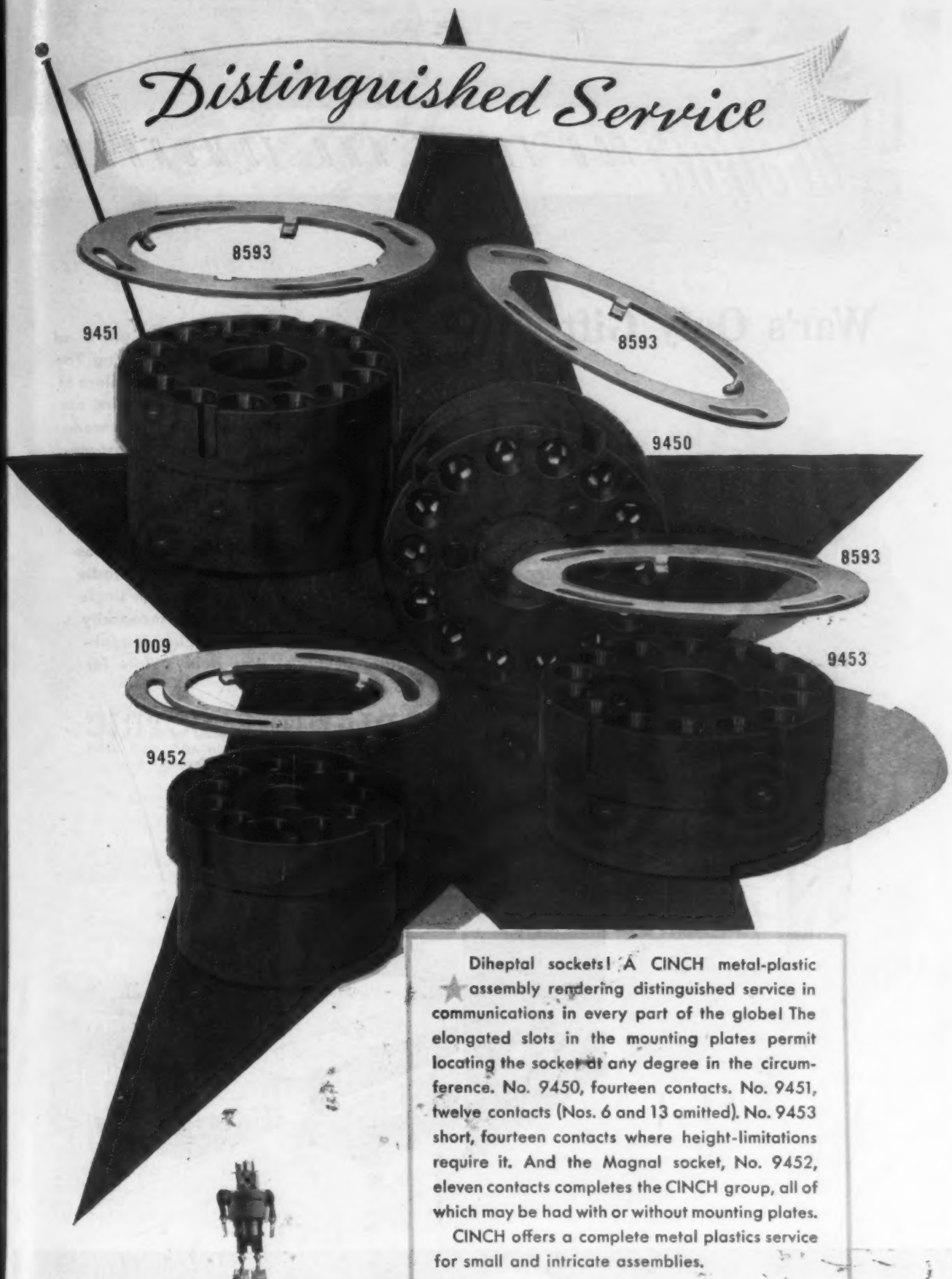
* Note that the phase velocity is greater than that of light.

Values of kb Corresponding to Different Modes of Transmission in Cylindrical Wave Guides

$TM_{n,m}$ Waves			$TE_{n,m}$ Waves		
n	m	kb	n	m	kb
0	1	2.40	0	1	3.83
0	2	5.52	0	2	7.02
1	1	3.83	1	1	1.84
1	2	7.02	1	2	5.33
2	1	5.14	2	1	3.05
2	2	8.42	2	2	6.71


UNIVERSAL WAVE GUIDE CHART
For Circular and Rectangular Wave Guides
Excited in TE or TM Mode
α – attenuation constant in nepers/cm
β – phase constant in radians/cm
λc – cut-off wavelength in cm
λ – impressed wavelength in cm
vp – phase velocity in cm/sec
vg – group velocity in cm/sec
v – velocity of light in cm/sec in unbounded dielectric having same properties as dielectric in guide
(Note: For hollow wave guides, v=3x10^10 cm/sec)
Attenuating Constant x Wavelength (αλ)
Phase Constant x Wavelength (βλ)
Wavelength Ratio λp/λ and Velocity Ratios vp/v and vg/v
Wavelength Ratio λ/λc or Frequency Ratio fc/f
αλ
βλ
λp/λ
vp/v
vg/v

Distinguished Service



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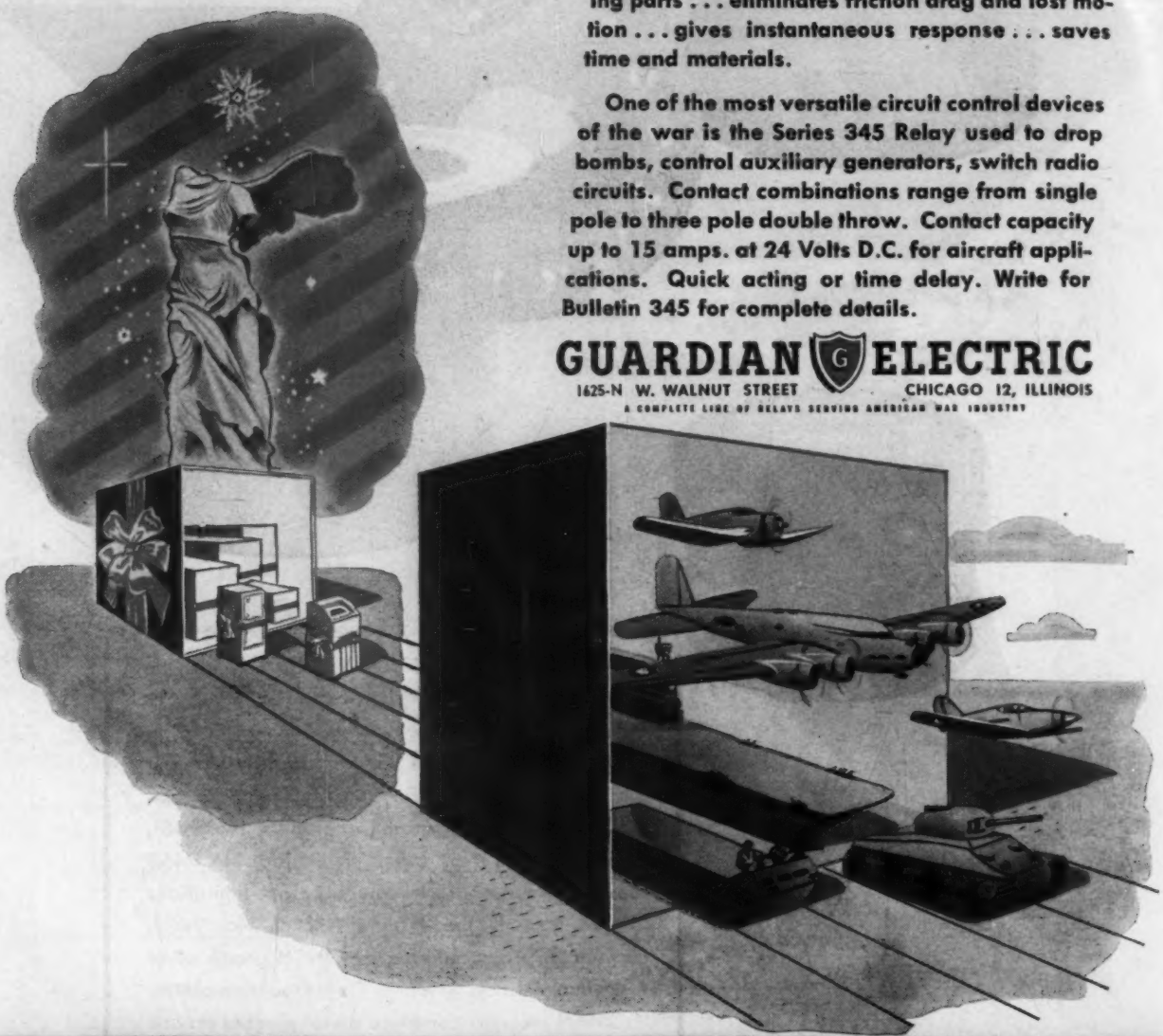

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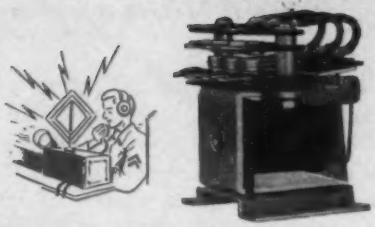
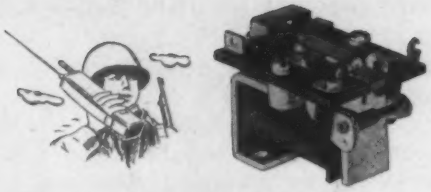


SERIES 345 RADIO RELAY

A general purpose radio relay designed for aircraft use. Contact combinations up to three pole, double throw. Coil resistances range from .01 ohm to 15,000 ohms. Standard voltage: 16-32 volts D.C. Available with delayed release or delayed attract. Weight: 6½ oz. Also built for A. C. operation (Series 340).



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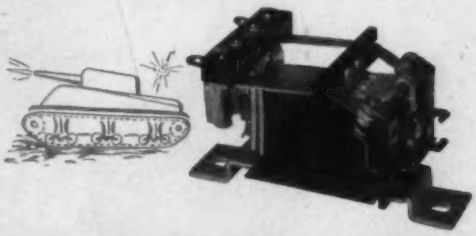
One of the smallest of all relays. Built for aircraft and radio applications where space and weight are at a premium. Contact rating: 2 amps. at 24 volts D.C. Switch capacity up to double pole, double throw.



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TUBES AT WORK

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Noise from cannon and chattering machine guns is not transmitted as well as voice signals by the lip microphone

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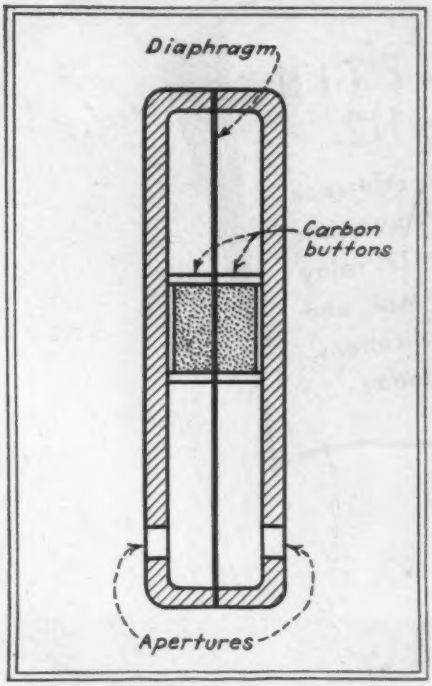
A NEW TYPE of carbon microphone being used by the armed forces is worn on the upper lip of the operator. It permits reduction of unwanted background noise by an acoustical balancing arrangement that effectively cancels sounds that originate at a distance from the microphone. This is useful in locations, such as in tanks, where the noise level produced by the mechanical equipment and armament is high and is ordinarily transmitted almost as effectively as the desired voice signals.

The basic construction features of the microphone are shown in the drawing. It consists of two carbon buttons arranged on both sides of a diaphragm, and the whole enclosed by a case that forms two cavities, one on each side of the diaphragm. Only one of the carbon buttons is electrically connected; the other button is included to help maintain physical balance between the two sides of the diaphragm.

Operation

Two apertures are provided near the base of the microphone casing to allow sounds to enter the cavities. If the physical balance is accurate, sound waves enter both apertures and, if they are equal in amplitude and phase, will create equal and opposite pressures on the sides of the diaphragm. However, a difference in amplitude or phase of the sound waves will cause a sound pressure differential between the two surfaces of the diaphragm and it will be caused to move in direct proportion to the degree of the differential. For this reason the microphone is termed a differential microphone by the manufacturer, Electro-Voice Mfg. Co., Inc.

The discrimination between near by sounds and more distant sounds



Cross-section of the lip microphone, showing the apertures through which sound waves reach the cavities on each side of the diaphragm

The lip microphone is supported in position by a harness that loops over the operator's ears like spectacles and permits wearing a gas mask or respirator during operation. A thin plastic film seals out moisture

IRC TYPE MP RESISTORS

Keeping America's newest broadcasting F M and television transmitters operating with a minimum of interruption or distortion is a challenging job. There's no room for chance with thousands of dollars of air-time and talent services at stake. To make certain that transmitters and control instruments will function perfectly under their full power loads—often running to 50 kilowatts—daily tune-up tests at off-time periods have become standard practice. But to throw this unbridled wattage out over the regular antenna could conceivably cause air-signal havoc . . . squeals . . . crashes . . . shot noises.

So, one of the early F M and television problems faced by broadcast engineers was the development of a dummy antenna simulating the high frequency characteristics of the regular antenna, in order to obtain informative and accurate check-readings.

ANOTHER IRC APPLICATION

I R C's M P Resistors, when water-cooled, furnished the ideal solution. These sturdy units embody all the required features while readily dissipating the tremendous heat factors involved.

Tests indicate that water-cooling at tap pressure increases their rating by as much as 90 times.

If resistances will play a part in your post-war products, consult I R C. You'll obtain unbiased engineering counsel, for I R C makes more types of resistors in more shapes for more applications than any other manufacturer in the world.

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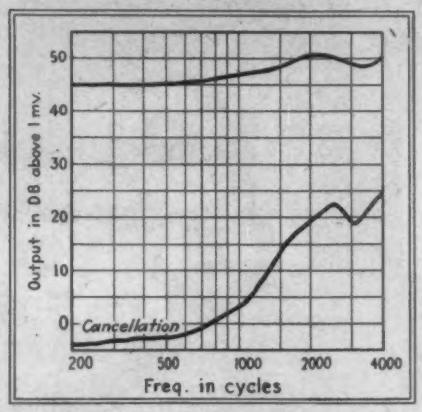
is due to the differential action. Thus sound waves originating close to one aperture may travel four times as far to reach the other aperture. The differential in this instance would be sixteen and only a negligible amount of cancellation would result. At the same time, sound waves from a source several feet distant would reach both apertures at almost the same time and the differential, the ratio of the distance traveled by the waves, would be almost unity. The amplitudes of the two waves are then almost identical and cancellation takes place.



Response curve of the lip microphone and a curve showing the amount of noise cancellation obtained. The space between the curves shows in decibels the difference between the voice output and the noise output

This principle of operation assumes a sound source of negligible area and, although it has been found that the area of a speaker's mouth produces some diffusion, the loss due to cancellation of speech is relatively small.

Extent of Cancellation

The space between the apertures in the lip microphone is about one-half inch and this provides effective cancellation up to about 4,000 cps, entirely adequate for communication purposes. The spacing is kept small since it may represent an appreciable fraction of a wavelength at the higher frequencies, with the result that the pick-up at the two apertures may be sufficiently out of phase to reinforce one another rather than cancel at these frequencies. If this occurs, certain interfering frequencies are emphasized rather than suppressed.

The degree of cancellation of unwanted noise by the microphone is shown in the curve. This represents the noise output with the microphone subjected to ambient noise at a plus 113.8 db level. The area between the curves represents the difference in db by which the speech output of the microphone exceeds the noise output with this value of ambient noise.

The differential microphone has been designed to fit inside of a gas mask or respirator without breaking the seal where the mask fits the head of the wearer, and is electrically interchangeable with standard Army microphones. Because of its location during use it was necessary to make the unit impervious to moisture. This has been accomplished by covering the apertures with a thin membrane of plasticized film that does not materially interfere with the passage of sound waves. The film has a thickness of only 0.0004 inch and introduces a loss of less than 2 db throughout the frequency range from 200 to 4,000 cps.

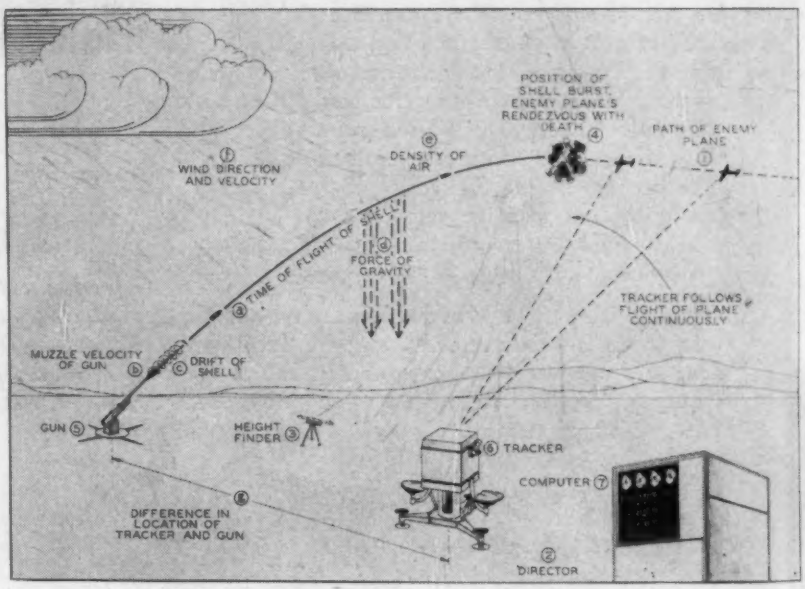
Electrical Director for Anti-Aircraft Guns

THE M9 ELECTRICAL GUN director aims an anti-aircraft gun and sets the shell's fuse so that the burst will occur within lethal distance of a hostile aircraft. It differs from other directors, which employ mechanical movements, in using electrical circuits to make its calculations.

How the electrical director works is shown in the illustration. When an enemy plane (1) looms in sight, the crews of the tracker (6) and of the height finder (3) spot the target and follow it in its flight. The computer (7) of the electrical director instantly measures the position of the target and then predicts where the anti-aircraft gun (5) is to be aimed and how the fuse of the shell is to be set so that the shell will burst in the path of the plane at the predicted position (4).

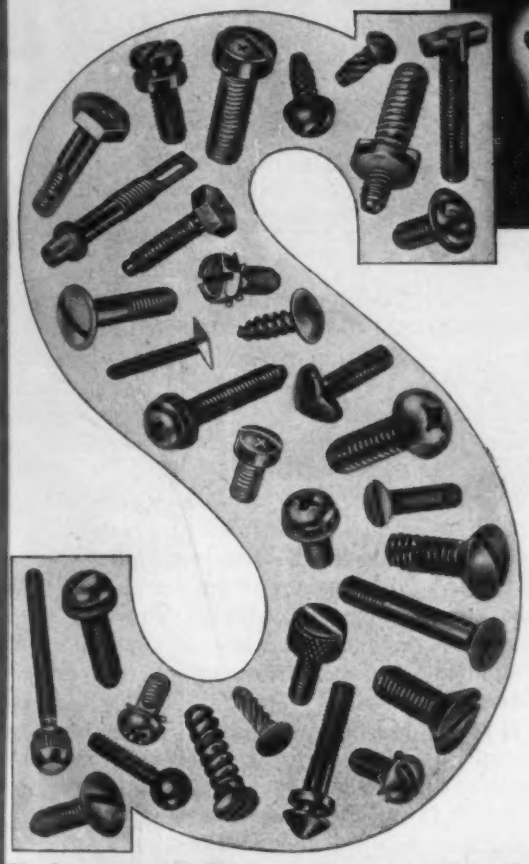
The electrical information derived by the computer is translated into mechanical movement at the gun to swing its muzzle automatically to the correct horizontal and vertical angle to score a hit. Not only must the computer make its calculations continuously during the entire period the target is being tracked, but it must make constant and instantaneous corrections for a number of factors.

The time of flight of the shell (a) to the predicted position of the target (4) is dependent upon the muzzle velocity of the gun (b), which in turn is governed by the temperature of the powder and the number of times the piece has been fired. The path of the shell is also influenced by its drift (c) which is the spin caused by the rifling of the gun, curving the shell to the right. At the same time the pull of gravity (d) deflects the


POSITION OF SHELL BURST, ENEMY PLANE'S RENDEZVOUS WITH DEATH ④
PATH OF ENEMY PLANE ①
WIND DIRECTION AND VELOCITY ⓕ
DENSITY OF AIR ⓔ
TIME OF FLIGHT OF SHELL ⓐ
FORCE OF GRAVITY ⓓ
TRACKER FOLLOWS FLIGHT OF PLANE CONTINUOUSLY
MUZZLE VELOCITY OF GUN ⓑ
DRIFT OF SHELL ⓒ
GUN ⑤
HEIGHT FINDER ③
⑥ TRACKER
COMPUTER ⑦
DIFFERENCE IN LOCATION OF TRACKER AND GUN ⓖ
② DIRECTOR

How the electrical director works. When an enemy plane looms in sight the computer predicts where the anti-aircraft gun is to be aimed and how the fuse of the shell is to be set so that the shell will burst in the path of the plane at the predicted position

TYPICAL PROBLEMS SOLVED BY SCOVILL COLD-FORGING "KNOW HOW"



Our business is *quality* special and standard cold-forged parts in quantity. Thus far this year we've shipped nearly a billion pieces—most of them war work—working in nearly all common metals.

Our stock-in-trade is unusual "know how" that makes cold-forging save money—metal—motions for our customers. Illustrated above are a few of the tough "specials" that show what we can do.

The same "know how" that makes us custom tailors in cold-forged parts also makes it possible for us to sell quality standard screw products at ordinary prices. Shown in the "S" are a few of our wide range of standard fastening devices.

It will pay you to talk over your present and postwar problems and needs with the nearest office listed below. Occasionally, our war commitments temporarily tax our capacity, but every inquiry receives a prompt, frank answer as to when and how we can be of service.

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To the Reader: ***Kindly route this on to others to whom our "know how" can be helpful.***

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shell downward, and the varying density of the air (e) slows down the projectile more or less, while the direction and the velocity of the wind (f) either retards or pushes the shell ahead or to one side. To add to the complications of the problem, the difference in the location of the tracker and the gun (g) must also be taken into account.

This development in Army ordnance was shown recently when the Army and Bell Telephone Labs. jointly demonstrated the electrical gun detector at Murray Hill, N. J. Western Electric Co. builds the directors.

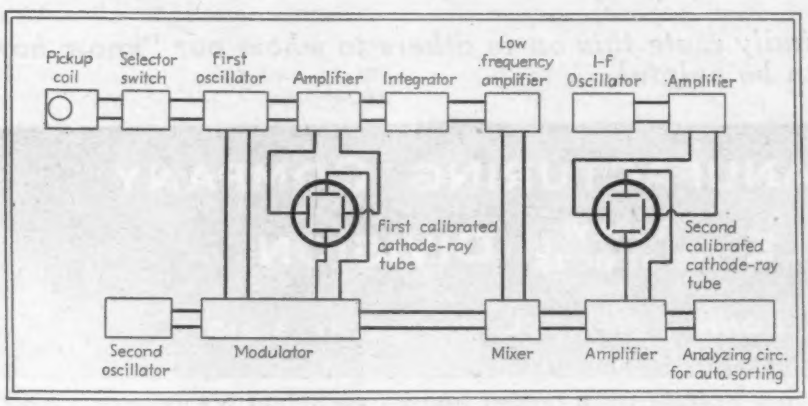
Strangely enough, the director originated in a dream. One night in the middle of 1940, Dr. David B. Parkinson awoke with the impression that he had been a member of an anti-aircraft gun crew, which brought down a plane with every shot. Somehow he knew that in the gun control mechanism was an electrical device somewhat like something he had been working on in Bell Labs. A possible solution was communicated to the Navy and the Army; the Anti-Aircraft Artillery Board promptly endorsed the venture and the OSRD agreed to finance it. A week before Pearl Harbor, a model had been delivered to the Army for test.

Testing the hardness of armor-piercing shot with the Cyclograph. Special controls, locked behind the center panel, are adjusted by the factory technician for different test routines

Electronic Metal Tester

A NEW INSTRUMENT provides a nondestructive means of determining differences or variations in the metallurgical properties of metal parts or stock. It performs both qualitative and quantitative analysis of both ferrous and nonferrous metals and permits evaluating and sorting such materials according to their metallurgical properties. This is accomplished by placing a tuned pickup coil around the piece to be tested, so that the variations in core loss indicate the metallurgical properties.

The stages comprising the instrument are shown in the block diagram and form the Cyclograph, developed by the Allen B. DuMont Laboratories. It contains two five-inch cathode-ray tubes, each tube being supplied by a separate oscillator. Another oscillator is arranged so that it feeds both cathode-ray tubes through a modulator and mixer arrangement.



Block diagram of the stages in the Cyclograph, a new instrument for electronic sorting or analyzing of metal parts without impairing the sample

The instrument functions as a comparator and is calibrated for each application by establishing a cyclogram for a given standard so that variations in height or other selected factor from the standard reading are indicated on the screen.

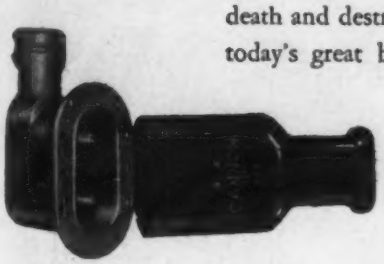
The instrument has been successfully applied to sorting metals whose significant metallurgical properties are constant except for the one property to be examined. However, many commercial steels do not conform to this condition of uniform metallurgical properties. Preliminary selection by inspection of the core loss characteristics at several frequencies by the instrument permits breaking down the lot into smaller lots that will have reasonably constant metallurgical properties except for the single property under test. The Cyclograph then evaluates the single property for each of these lots.

Successful applications of the instrument include the sorting of metals, evaluating the brittleness of armor-piercing shot, hardness gradients, and measurement of case depth. An interesting application is the sorting of common grades of SAE and NE steel in which two or more frequencies are used to give a correlation between the instrument readings and the characteristic of

In this war of many fronts, half-ton block busters are lifted by winch and motor into the yawning bellies of giant bombers . . . to spread death and destruction on our axis enemies. But today's great bombers, destruction bent, may seem puny in the light of tomorrow's aircraft, pursuing peacetime missions.

Great loads . . . entire boxcars in fact, may be the given load of aircraft in future peacetime years. And whether it's a carload of broccoli from California, a boxcar of bananas from the Tropics or pineapples from Hawaii . . . the energy expended in loading, lifting and also in flying will unquestionably be dependent in part on electrical circuits.

And wherever electrical circuits are involved, there you will more than likely find Cannon Connectors. For Cannon Connectors are used wherever electrical connections must be made quickly and with absolute certainty . . . in planes, tanks, communications, motion picture studios and hundreds of other civilian and military uses.



The two Cannon battery connectors above are a part of the complete line as shown in Cannon's latest Battery Connector Bulletin. Write today on your business letterhead for a copy.

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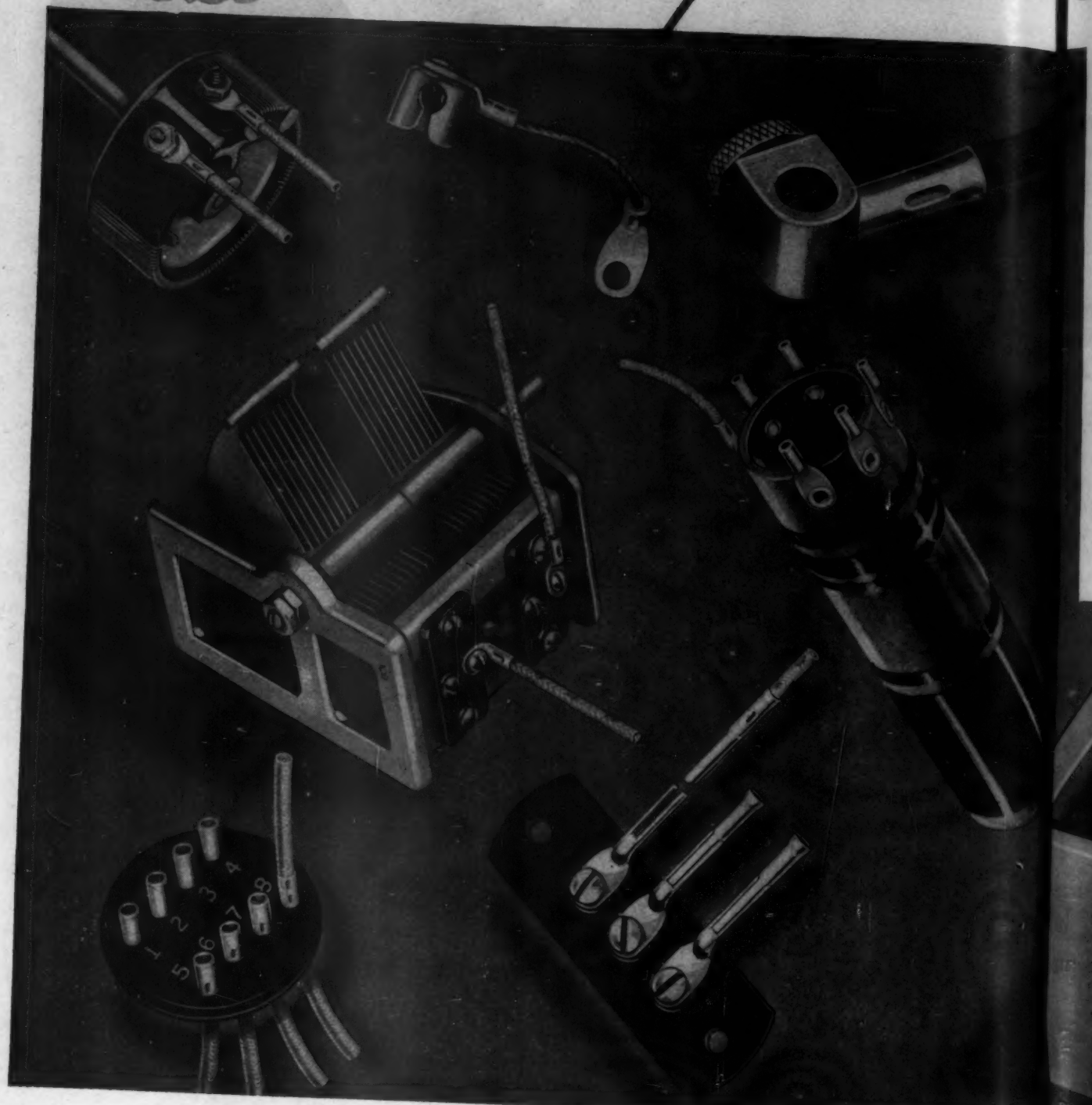

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Burndy . . . pioneer in solderless electrical connectors...is working closely with leading designers and manufacturers in applying the economies and advantages of indent type connectors to component parts manufacture, and final assembly. In most cases, standard HYDENT connectors are used; in others, Burndy has designed special connectors for the job. In *all* cases, the indent type connection has simplified and stepped-up production, provided a better connection mechanically and electrically, and materially lowered costs.

If you are still using soldered connections, why not investigate thoroughly the advantages of the solderless indent type? Complete engineering cooperation is yours for the asking . . . from connector headquarters. Write or phone to-day.

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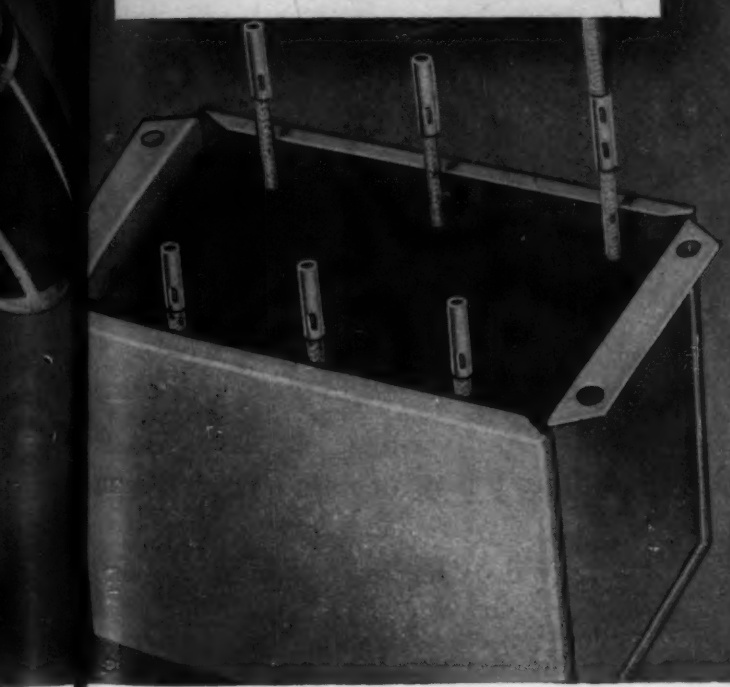

A few of the many types of
Burndy HYDENT CONNECTORS

Headquarters for CONNECTORS

Burndy

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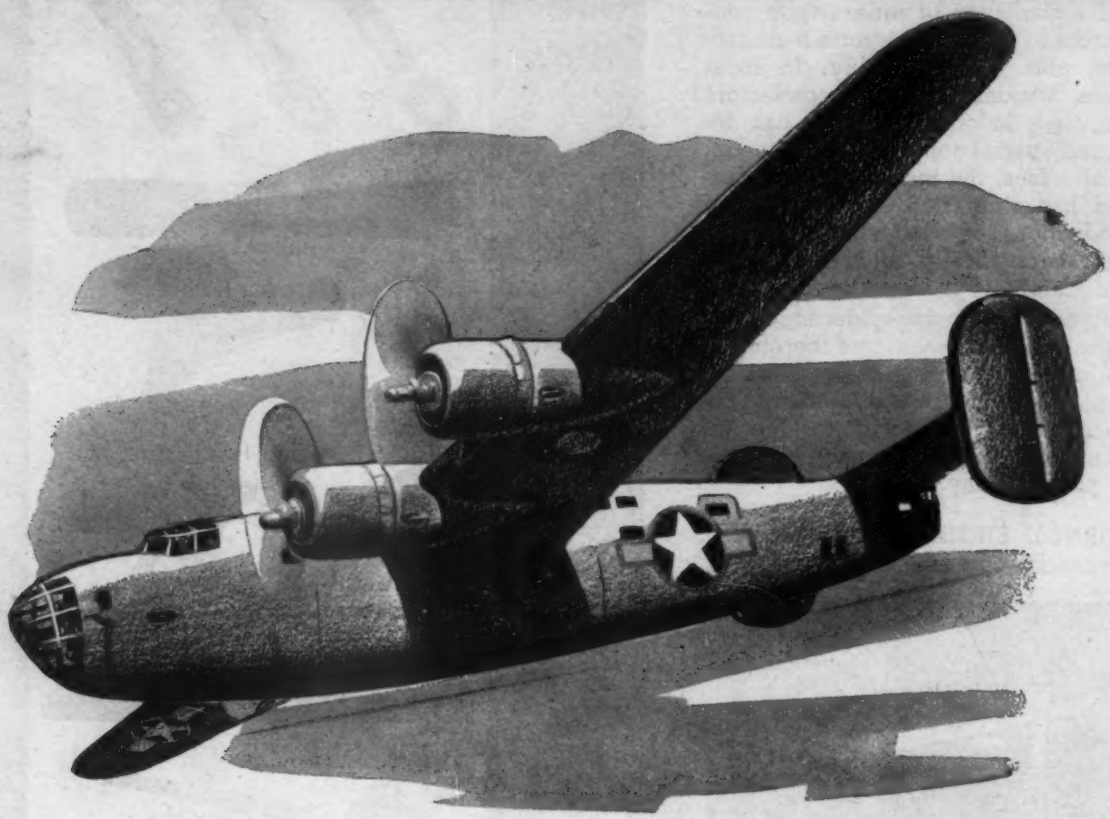

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Our Liberators are winging global routes, chartered and uncharted, in the fight to make all men free. Wherever military or civilian planes fly, Wilcox Radio equipment is helping maintain dependable communications.

the metal which is to be identified.

If an attempt were made to separate the two different steels at one frequency, sooner or later some pair of steels would be encountered which would give the same reading. This is true of all methods of magnetic testing that use only one reading. This condition can be overcome by measurements at three different frequencies, such as 3, 10 and 50 kc, to definitely establish any particular steel.

Packaged welding rods being checked to see if they are all made of the same material. A single rod of different composition shows up in a package of 50

To separate two steels, a composite indication at two frequencies other than the measuring frequency furnishes a reading typical of each grade of steel for the standardizing reading. The standardizing reading is then taken of each piece of steel. If the reading is one of the two values expected, the measuring indication shows which one of the two steels is the particular piece. If the standardizing reading is not one of the two expected readings, the steel is neither of the two steels the instrument is supposed to be sorting, or else it is not in the expected state of heat treatment.

A similar procedure is used in the identification of certain conditions in nonmagnetic metals. Changes in physical properties such as are produced by age hardening in aluminum alloys, cold working of brass, or drawing of nonferrous wire produce characteristic changes in the curves. They may be used in the same manner to sort these according to the extent of variation in some one or more physical properties.

Where the quantity of pieces to be tested is large an automatic relay can be used. Small pieces, such as bullets or screws, can be sorted at a rate of about five per second.

Electronic Stop for Textile Machines

By A. P. MANSFIELD
Industrial Engineering Division
General Electric Co.

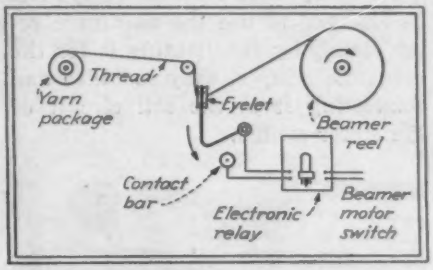
THE "STOP MOTION" mechanism of a textile machine has a vital function in assuring that the machine's output is of high quality. This is true whether the machine is being used to prepare the threads, weave, or knit the cloth.

By far the majority of "stop motions" are of the electrical type with their action depending on the making of a positive electric contact at the instant a thread breaks. Should there be a delay in this contact, or otherwise faulty action, the broken end will pass on into the finished goods and result in an imperfection.

From the practical standpoint, the mechanism used to detect thread breaks must be small and light, easily set and adjusted, and must not interfere in any way with the normal thread motions. At the same time, it must be safe from both the operator and fire hazard viewpoints. These stipulations dictate the use of a low-voltage, low-power control circuit.

A further complication is the fact that the air in textile mills is laden with lint and dust to varying degrees depending on local conditions. It is also highly humid. Under these conditions, the contacts on the "stop motion" drops may become coated, which ultimately leads to definitely unreliable operation.

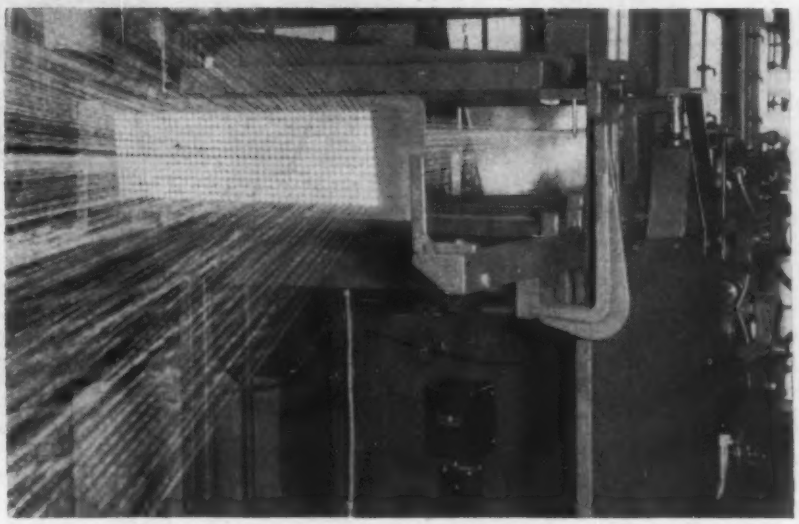
Obviously, therefore, a device that will contact infallibly in spite of these conditions and at the same time introduce no new hazards, is required for complete "stop motion" protection. The electronic relay recently developed by General Electric does just this.



When the thread breaks on a textile beamer machine the arm supporting the eyelet drops to the contact bar and closes the input circuit of the electronic relay. This in turn shuts off the beamer motor switch

This electronic relay is basically an electronic tube amplifier that is arranged as shown in the diagram. Just before the threads come to the beamer each thread passes through a hinged eyelet, called a drop switch. When the threads are wound on the beamer they are in tension and hold the drop switches in an open position. When a thread breaks it is no longer in tension and the drop switch, its weight unsupported, drops to the metal bar.

The contact to the metal bar causes



Electronic relay attached to a textile beamer machine to stop the motor when one of 500 threads breaks

a minute current flow in the input circuit of the relay tube. This current, only a few microamperes, is amplified by the tube which in turn operates a relay in the output circuit. The relay then opens the coil circuit of the motor switch and stops the beamer machine. Entirely satisfactory operation is obtained with the resistance of the "stop motion" contact circuit as high as 500,000 ohms.

Existing "stop motion" relays can be changed to use the electronic relay simply by substituting it for the magnetic relay already installed and connecting it to the coil circuit of the motor switch.

Assembly of thread drop switches and contact bars for electronic control of a beamer machine in a Van Raalte silk mill

The photographs show an example of an electronic relay application in the textile industry where it is used to stop a beamer almost instantly should any one of 500 threads break. Electronic relays are equally applicable to beamers handling several thousand "ends".

Before the electronic relay was installed, trouble was encountered in using a standard magnetic relay and having the thread "stop switches" operate it directly. The difficulty resulted primarily from the thread ends and thread dust which, in the presence of moisture, fouled the contacts.This fouling resulted in a high-resistance contact that did not permit sufficient current flow to operate the magnetic relay. Because the electronic relay can operate reliably and safely on a high-resistance circuit, it has proven satisfactory.

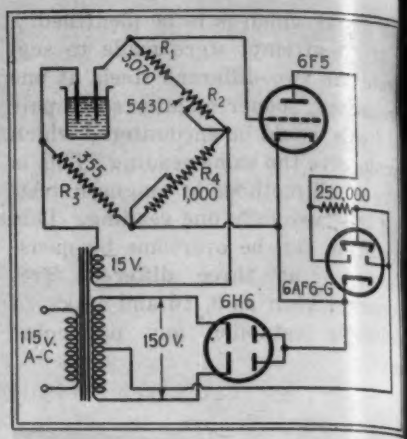
Water Purity Tester

TESTING THE PURITY of distilled water is simplified by means of the instrument shown in the diagram. It actually measures the conductivity of the water under test, but for convenience the scale is calibrated 0 to 15 parts per million in terms of sodium chloride so that the user obtains a direct reading.

The circuit is essentially that of an alternating-current Wheatstone bridge. A conductivity cell connected as shown in the diagram, together with the liquid in which it is immersed, constitute the unknown resistance. Resistors R_1 and R_2 are the standard resistors, and resistors R_3 and R_4 together with the slider on R_4 form the ratio arms of the bridge. Resistor R_2 is employed for temperature compensation and has a dial marked in degrees. A dial on resistor R_4 carries the concentration calibration.

Voltage for the bridge circuit is derived from a winding on the power transformer. Plate voltage for the operation of the 6F5 amplifier tube and the 6AF6G indicator tube is supplied by the center-tapped 150-volt winding of the power transformer through a 6H6 rectifier tube. The latter is arranged in a frequency doubler circuit.

The detector junctions of the bridge are connected to the grid and



Circuit of the Wheatstone bridge and electronic amplifier that actuates the indicator tube in the purity meter. A 6H6 rectifier supplies voltage at double the line frequency to the plates of the other tubes, without filtering

cathode of the 6F5 amplifier tube. Unbalance voltage from the bridge circuit is applied to the grid and cathode of the 6F5 amplifier tube and tends to close the shadow angle of the indicator tube. When the voltage across the detector junctions is zero the indicator tube is opened to its maximum shadow angle. Throwing the bridge off balance in either direction results in closing of the eye.

If the amplifier and indicator tubes were operated at the line frequency instead of twice line frequency, the eye would open if the bridge were thrown off balance in one direction

Output of a laboratory still being tested for purity by means of a Wheatstone bridge and tuning eye tube

for the Future OF ELECTRONICS··

"A-N" CONNECTORS

Army-Navy specification electrical connectors, manufactured in every required size and type by Amphenol, are made for many applications—in electrical and communications systems of airplanes, tanks, ships—for special applications in the field of electronics. The use of Amphenol Connectors assures dependable service.

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Flexible aluminum and synthetic covered conduit to A-N specifications. Amphenol A-N specification conduit fittings include: ferrules, coupling nuts, adapters, cable clamps, straight and angle couplings—all necessary fittings for complete conduit assembly work.

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Amphenol Coax and Twinax Cables with ultra low-loss Copolene B or beaded type polystyrene represent the ultimate in high frequency transmission lines—their use assures the uniform low-loss characteristics required in high frequency or micro-wave installations. Used with Amphenol Type 83 Coax and Twinax Connectors for perfectly balanced assemblies.

AMPHENOL POLYSTYRENE

Clear, transparent Amphenol polystyrene—custom machined with special equipment under ideal production facilities—will save you waste and worry in fabrication. The useful combination of properties characteristic of this material offers unlimited advantage in the field of electronics. Also Amphenol polystyrene rods, sheets, and welding cement (Polyweld).

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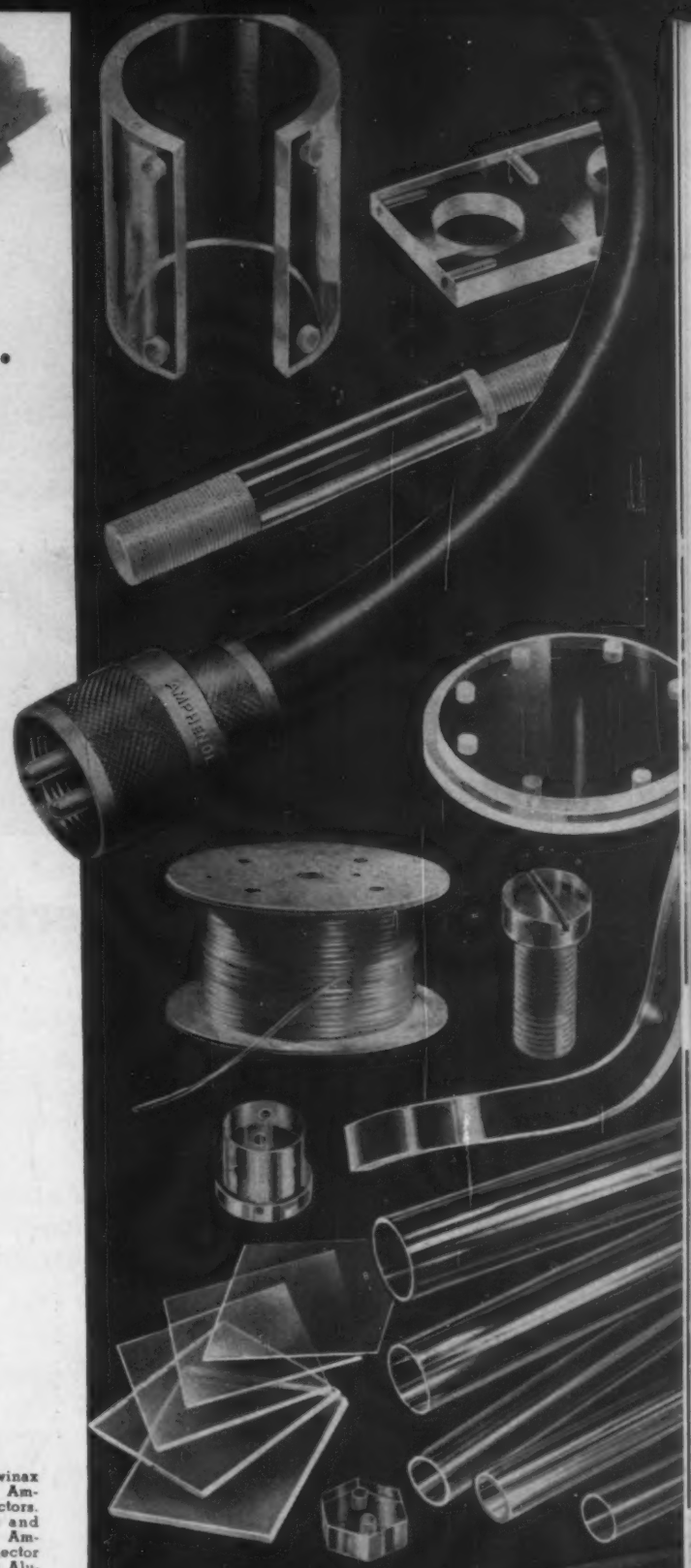

ILLUSTRATED:
Amphenol Coax and Twinax Cables equipped with Amphenol Type 83 Connectors. Machined Polystyrene and other plastic products. Amphenol AN-3108 Connector with Amphenol Flexible Aluminum Conduit.

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★ The facilities of THE H. A. WILSON COMPANY permit manufacturing customers to secure both electrical contacts and thermostatic bimetal from a single source. This is important because materials from these two groups are frequently used in conjunction, as parts in the same device. The most effective use of one necessitates a knowledge of the other.

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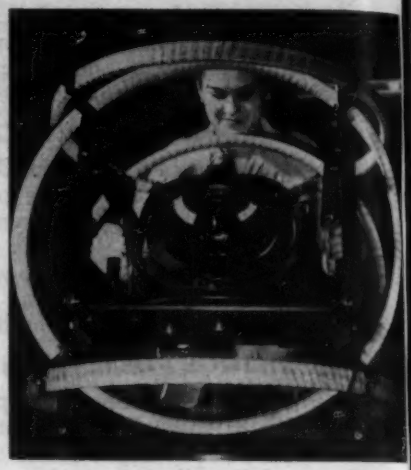
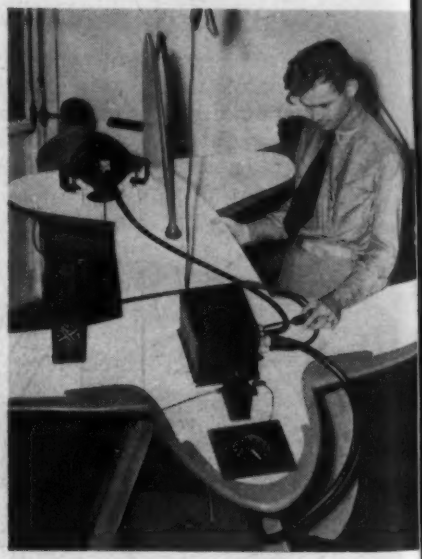
Gyro Flux Gate Compass

A NEW COMPASS for aircraft, termed a gyro flux gate compass, eliminates some of the disadvantages of the traditional magnetic compass and its need for constant correction during flight. The instrument contains a gyroscope that rotates at a speed of 10,000 rpm to keep the mechanism level during flight, and a set of coils so arranged that they intercept the magnetic field of the earth and cause electrical impulses through their windings. The pickup coils may be mounted anywhere in the plane. The impulses are transmitted to an amplifier which connects to an indicator having a dial similar to a conventional magnetic compass.

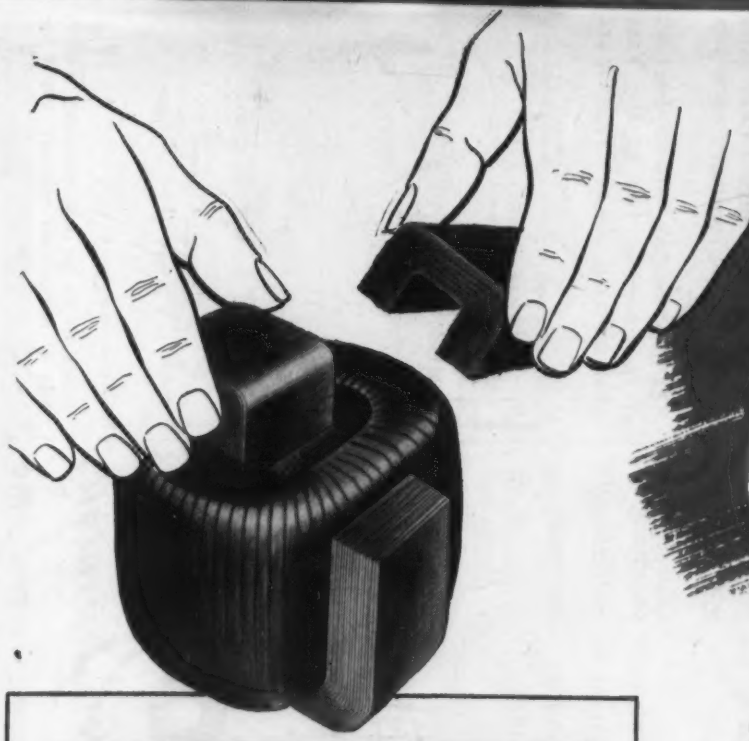
The indicator mechanism auto-



Transmitter assembly of the gyro flux gate compass, being tested in the field of pickup coils



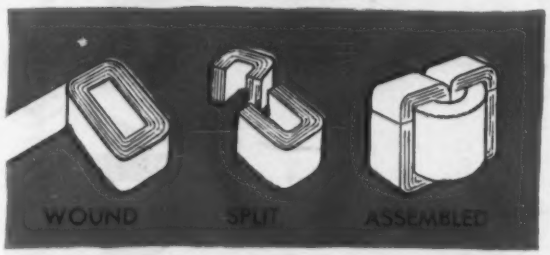
Demonstration unit showing the compass transmitter on the tail of a model plane and the amplifier in the center of the fuselage. Each indicator corresponds to a compass card and pointer



SPEED UP

UHF coil assembly

...two-piece cores of HIPERSIL* save "stacking"



HIPERSIL Type C Cores are *preassembled*. A single strip is wound to form, bonded, then cut in two for easy assembly around windings.

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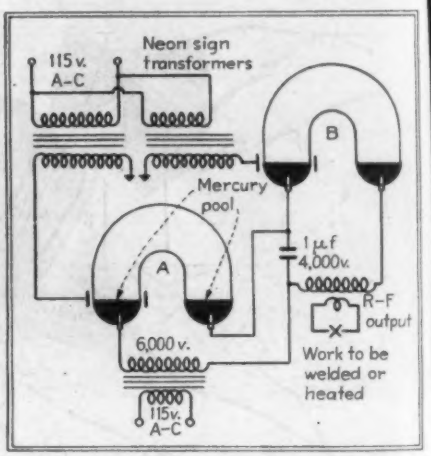
matically corrects errors resulting from interference caused by stray magnetic fields from metal objects and electrical equipment in the plane. Auxiliary indicators may be connected to the instrument as shown in the photograph of the demonstration model. This permits the pilot and the navigator to have simultaneous direction readings. The complete instrument is a development of the Bendix Aviation Corp., who report that the compass is unaffected by climbs and dives of the plane and does not lag or overshoot its reading during turns.

• • •

Electronic Circuit for High-Frequency Welding

THE APPLICATION of an external-control, two-element mercury-vapor discharge tube as a half-wave rectifier and as an enclosed spark-gap in a high-frequency welding circuit was described by Alfred Vang at the October 11 meeting of the American Welding Society in New York City. The tube developed by Mr. Vang consists of a U-shaped envelope of Pyrex containing a quantity of mercury, with tungsten wire electrodes inserted in each end to make contact with the two mercury pools, as shown in the accompanying diagram. Conduction is initiated at the mercury pool by means of high voltage applied to the metal ring encircling the end of the tube. This high voltage is obtained from an ordinary neon sign transformer.

In the welding circuit described at the meeting, two of the Vang tubes are used, one as a rectifier and



Simple circuit for high-frequency welding with a two-element mercury vapor discharge tube

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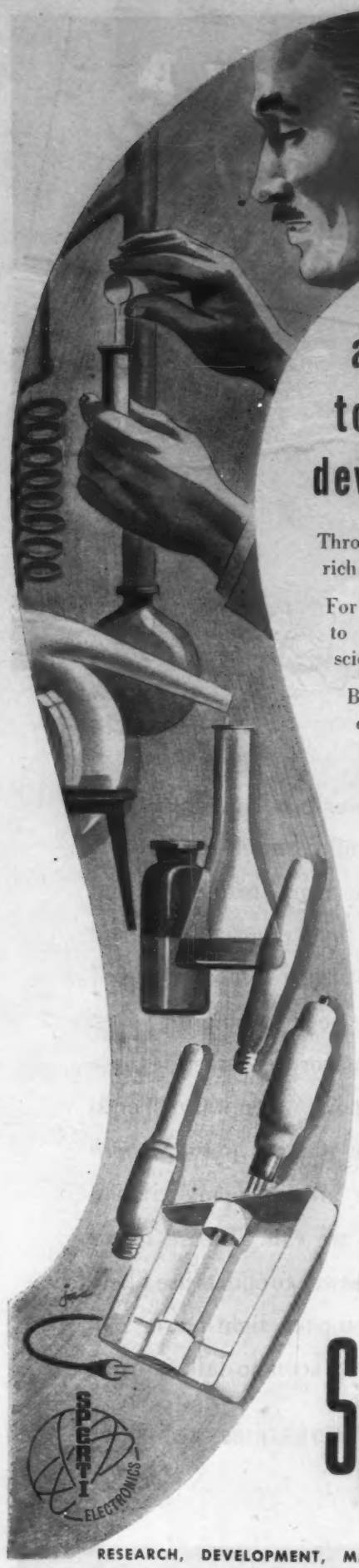

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the other as a spark gap, in an arrangement similar to that used in spark-gap generators for high frequency needs. On one half of the power line a-c cycle, tube *A* in the diagram is made conductive by its neon transformer, permitting the 6,000-volt secondary of a heavy-duty power transformer to charge the 1-μf capacitor through rectifier *A*. Tube *B* is nonconductive during this half-cycle because connections are such that its outer starting ring and inner mercury pool are at the same potential during the entire half-cycle.

On the following half-cycle tube *A* does not conduct, but tube *B* is energized at one mercury pool by its starting electrode. Now the capacitor discharges through tube *B* and the primary of the r-f output transformer. This is an auxiliary discharge that generates a high frequency whose value is determined by the constants of the inductance and capacitor. Energy can be taken from the coil in this circuit for welding or high-frequency heating by coupling a few turns to the output coil. The process repeats itself for each succeeding cycle, with the capacitor being charged during the first half-cycle and discharged through the auxiliary circuit during the next half-cycle.

Power supply demands are only one-fifth to one-tenth that required by ordinary single-stage welding equipment. The extension of the method to high frequencies with adequate power permits successful welding of silver to steel, magnesium to cast iron and other difficult-to-weld combinations. Extremely thin metal sheets can be welded together with air-tight joints by the method because of the short heating time. According to Mr. Vang, thermocouples placed as close as possible to the welding junction show a maximum temperature rise of only 8 deg. C during welding. It has been used for the welding of 0.003 in. stainless steel.

The circuit is still in the formative stage, and was shown only in breadboard form at the meeting. Many of its applications come under restrictions of military secrecy, but the equipment is available to manufacturers who can show that the equipment would be useful to the war effort. Mr. Vang is chief research engineer with Stevenson, Jordan and Harrison, Inc., New York City.

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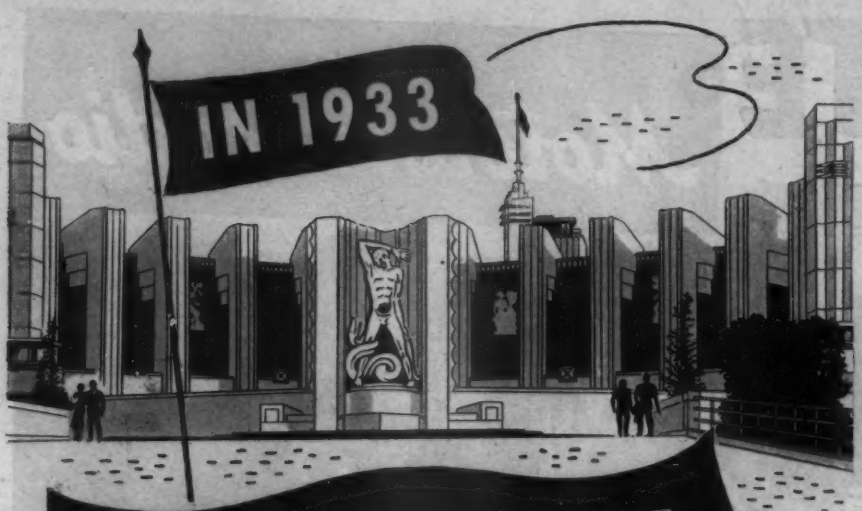

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Electronic Control of Gas-Cutting Machines

AN ELECTRONIC CONTROL that automatically guides a gas-cutting machine around a simple template composed of a pencil drawing on paper was described in a paper by R. D. McComb, of the Industrial Control Division of General Electric Co., at a meeting of the American Welding Society in Chicago during October.

One of the most important considerations in the design and operation of gas-cutting machines is that of guiding the machine smoothly, uniformly, and accurately about a drawing, contour, or template. A number of different types of control have been developed for this purpose utilizing a drawing, plywood, steel, and many other materials for the template, and using magnetic, spindle, track-type, or simple manual tracing devices on the machine.

The electronic control permits the template to consist of a piece of paper or white cardboard, upon which is drawn the shape which it is desired to reproduce. This may be done in heavy pencil, or in ink. Pencil is generally preferred since many of the templates are done on vertical drafting-boards. Corrections can also be made more easily in pencil. In order to obtain a more permanent template, it is possible to use a narrow ink line backed up by a wider pencil line, or to use a striping device to make a wide ink line. A thin coat of clear lacquer will help to prevent soiling of templates. Blueprints or black-and-white prints may be used as templates if the errors due to shrinkage of the paper, and slippage when passing through the blueprint machine, are not objectionable.

Standard gas-cutting machines have the gas-cutting torches mounted so that they follow exactly the motion of the axis of the tracing mechanism spindle which the operator guides manually about the template or drawing. For electronic control, the machine contains a steering motor, geared so that it may rotate the spindle in order to guide the machine. This motor simply performs the function formerly accomplished by the operator, namely, that of rotating the tracing-wheel spindle so that the tracing-wheel is guided in the proper direction.

As shown in Fig. 1, a drum *B* is geared so that it rotates with a ratio

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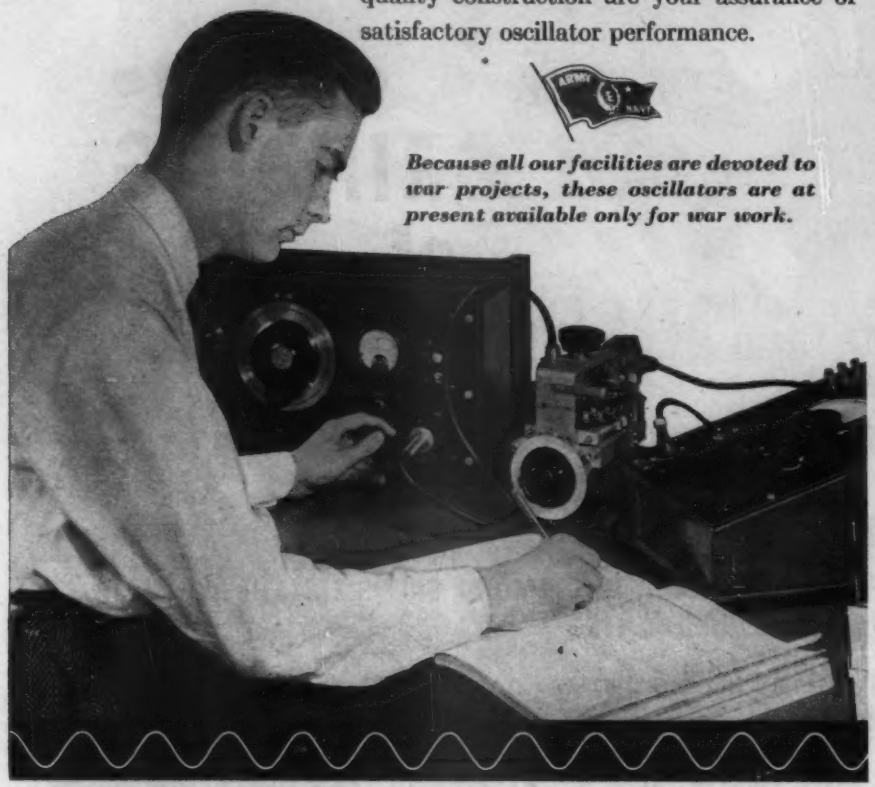
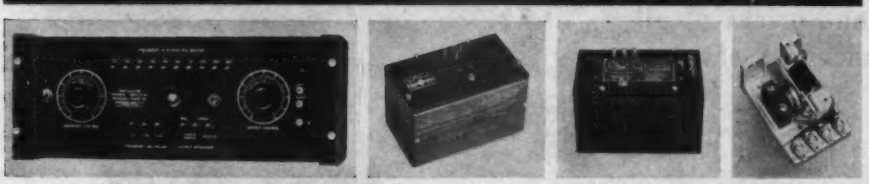


Because all our facilities are devoted to war projects, these oscillators are at present available only for war work.



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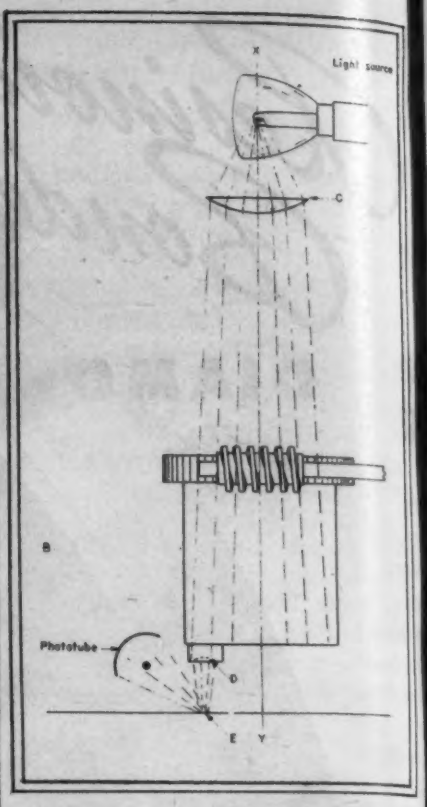

Fig. 1—Details of the optical system used for electronic control of a gas-cutting machine. A worm drives a gear to rotate drum *B*

of 1:1 with the driving spindle. This drum has a lens *D* mounted a short distance away from its center of rotation.

The drum is supported in bearings so that it may rotate about centerline *XY*. The light source and lens *C* flood the entire bottom end of this cylinder with light. Lens *D* collects some of this light and projects it in the form of a small spot on the paper template at point E. One or more phototubes are mounted so as to receive the light reflected back from the template. This reflected light causes an electrical signal to be produced which is proportional to the amount of light reaching the phototubes.

Since the amount of light which reaches the paper at point *E* is constant, the amount of light which reaches the phototube depends upon the surface of the paper at point *E*. If this is plain white paper, considerable light will reach the phototube and its electrical signal will be fairly large in magnitude. If a black line is drawn on the paper at point *E*, much of the light received from the optical system will be absorbed by this black line. Therefore, the amount of light reaching the phototube, and the pho-

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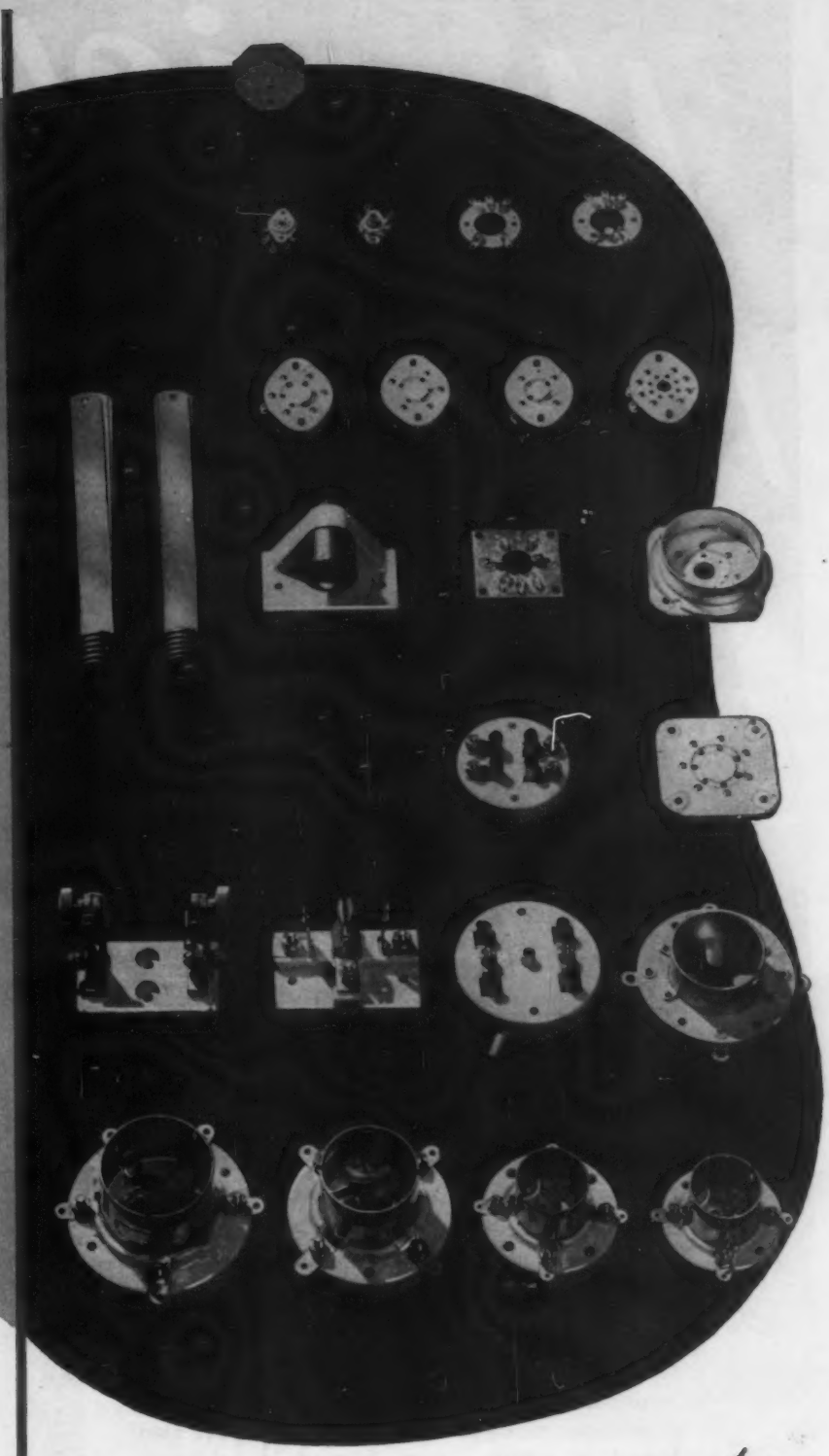

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totube's electrical signal in turn, wil be small.

Operation

The control is adjusted so that the steering motor is at rest when the spot of light is half on the black line and half on the white surface of the template adjacent to the line. If the spot of light moves in either direction away from its correct position, a signal is given to the steering motor to return it to its proper position. The circuit is arranged so that if the spot should approach closer to the line both the optical system and the driving spindle will be rotated in the counter-clockwise direction. If the spot should tend to leave the line and, therefore, strike the white paper surface, the optical system and driving spindle will move in a clockwise direction.

When following a curved line the steering motor is continually given a slight signal, due to the fact that the spot will always be traveling in the direction indicated by the driving wheel, and would therefore tend to leave the edge of the curved line if the steering motor did not turn the driving spindle clockwise.

Therefore, when following a curved line the spot will not quite be centered on the line, but will follow in such a manner that slightly more of its area is on the white paper template than is on the black line. In that way, a slight signal is continually given to the steering motor so that the control is smoothly turned around the circle and produces a smooth, clean cut.

Cutting Corners

The action of the control when steering the machine around the square corner is shown in Fig. 2. The spot approaches the corner as shown in *a* and *b*. In *b*, it is just beginning to leave the straight portion of the vertical line, and therefore, the photo tube is beginning to receive more light than it received in *a*. By the time the driving wheel has advanced the carriage to the position shown in *c*, the steering motor has begun to rotate the optical system and the driving head, and will continue to do so while the spot advances through the position shown in *d*. As shown in *e*, the control will position itself, with the spot approximately half on and half off of the black line of the tem

It's cold up yonder. Even the mechanical devices handled by men who fly the upper airways must be made of especially selected materials to withstand the low temperatures. This mobile microphone, designed for aviation communication, is a good example of the care the Signal Corps uses in selecting the right material for a specific job.

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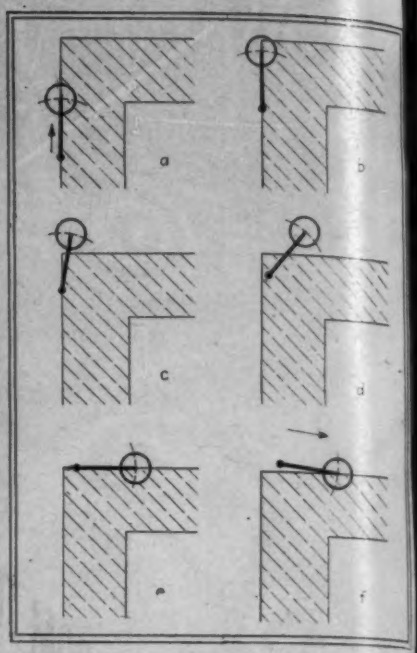

Fig. 2—Operation of the control in cutting a right-angle corner

plate, and, due to the inertia of the machine carriage, the true position of the torches may pass slightly beyond the new line of motion as shown in *f*.

Accuracy

As can be seen from Fig. 2, the true position of the torch does not correspond with the true position of the spot when going around a sharp curve or corner. If the machine is traveling quite slowly, as would be the case when cutting heavy material, the tendency of the driving wheel to skid after the control has turned the spindle through 90 deg. will be very small, and the cut obtained will be somewhat as shown at *a* in Fig. 3. If, however, the machine is operated at high speed, it might tend to skid beyond its proper position, and the cut obtained would be somewhat as shown at *b* in Fig. 3.

Most normal cuts will fall somewhere between the two extremes and will, therefore, produce the effect shown at *c* of Fig. 3, which consists of a slight rounding-off of the corner, plus a slight raised spot on the top surface of the cut.

However, the effect of these two errors is negligible. The distance from the center of rotation of the spot to the spot is never more than approximately $\frac{1}{8}$ inch. For many cases, this distance may be as small as 1/16 or 1/32 inch, and therefore

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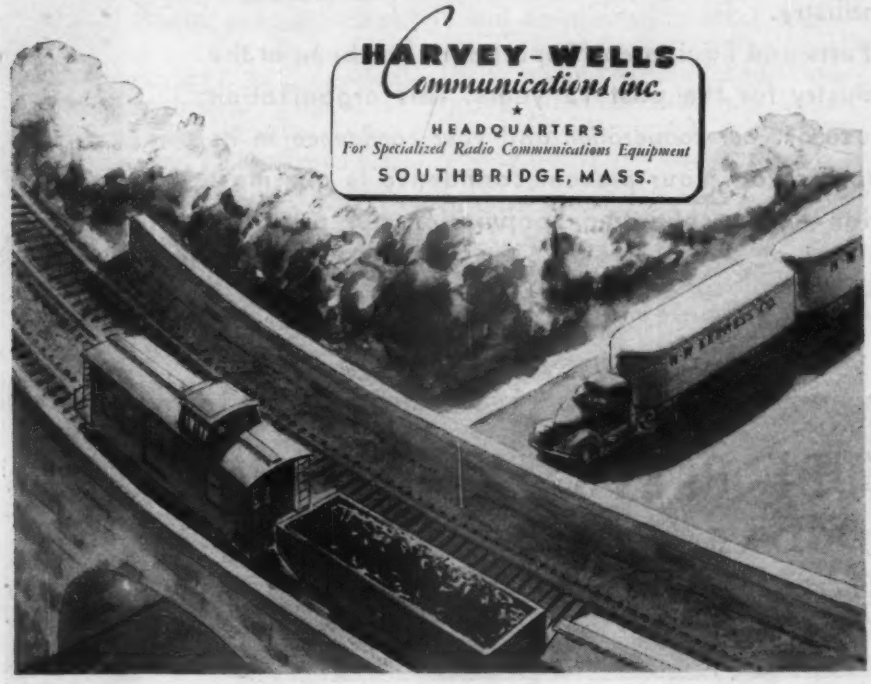

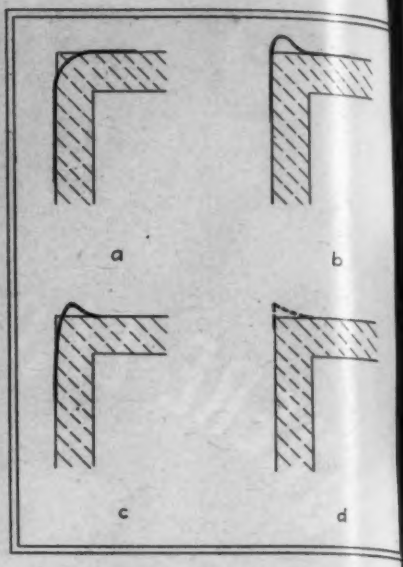

Fig. 3—Types of errors produced at various speeds: *a*—low speed; *b*—high speed; *c*—intermediate speed; *d*—change in template to correct error produced at low speed

this error will be correspondingly reduced.

If the distance between these two points were the maximum value ($\frac{1}{8}$ inch), then the error as shown at *c* in Fig. 3 would be 1/32 inch or less. However, in most cases it will be found that the small projection, which is located on the top flat surface of the cut, will be partially burned off, due to the fact that the torch heats this material on the trip up along one side of the template and, as it turns to follow the new path along the top of the template, this material (which has already been heated to quite a high temperature) is burned off easily. Therefore, the error involved will usually be even less than this 1/32 inch.

Theoretically, it would be possible to change the radius of rotation of the spot, so that for high-speed cutting this radius would be fairly large, and for cutting on heavy stock at low speed, it would be very small. In actual practice, it has been found that an intermediate adjustment will be satisfactory for almost all of the work that is encountered in machine gas-cutting today. If it is necessary to secure more precise operation, the template may be modified slightly, as shown at *d* in Fig. 3, so that a very nearly square corner may be obtained.

The diameter of the small spot of light on the paper is about 1/16 inch. Therefore, by the time the spot has moved 1/64 inch away from its cor-

EXCERPTS :

Dear Bill:

The answer is " YES ". Record Changers have top billing in our Post-war plans. After all, what

realistic about it. You're right again. There will be an unprecedented demand for Record Changers in Post war home phonographs. And we will have the capacity to handle it. Glad you remember our Pre-war Changer did make a hit back in '40 and '41.

Dear Russ:

Your letter bothers me because you have known us for years and must know that we don't talk until we are ready. We'll be happy to talk Post War Record Changers with you but don't ask us to show our hand right now... Don't worry... the new one will be a honey... our enthusiasm is unbounded and we won't be late. Please be patient. You will find

in the period immediately following the end of the war. What do you mean... WE are hoarding ideas ? We have asked you for your ideas and you know it takes time to adapt them.

Pre-War Model

you've got to hand it to the radio manufacturers. They know a good thing when they see it. And they don't forget. Like yourself they know about G.I.'s pre-war record changer.

Just wait til you see our new one. If your enthusiasm doesn't match ours I'll eat your hat. Sorry we can't unwrap the package for you right now. We've got to get on with the war. Army and Navy contracts

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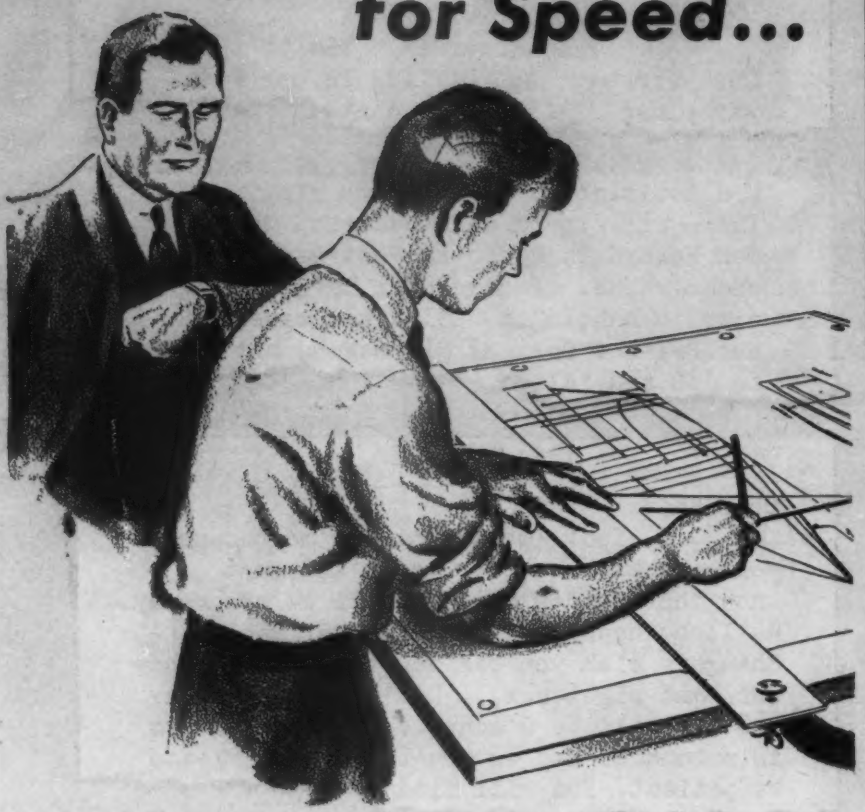

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If you're working under pressure, use Arkwright Tracing Cloths. Then you won't have to worry about erasures. You can erase easily and quickly because Arkwright Cloths have a smooth, almost smudge-proof surface. And you can ink over erasures neatly because both surface and base cloth are strong enough so they won't wear through. When time is important, choose tracing cloths carefully. Choose Arkwright! Arkwright Finishing Company, Providence, R. I.

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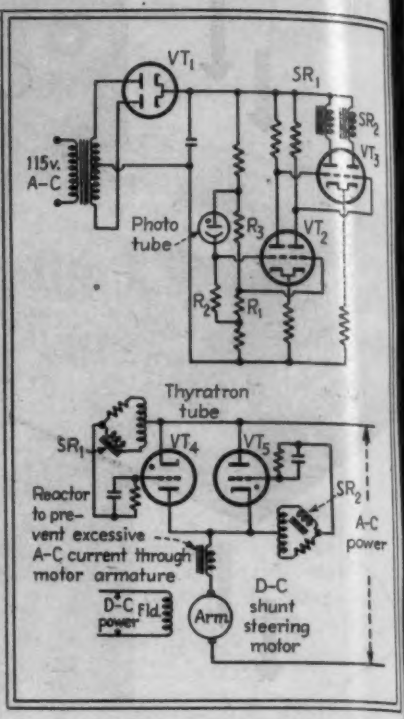


Circuit of electronic control unit that follows a pencil line and guides the flame of a gas-cutting machine. The d-c windings of the saturable reactors (SR_1 and SR_2) are in the upper circuit, and the a-c windings are in the lower circuit

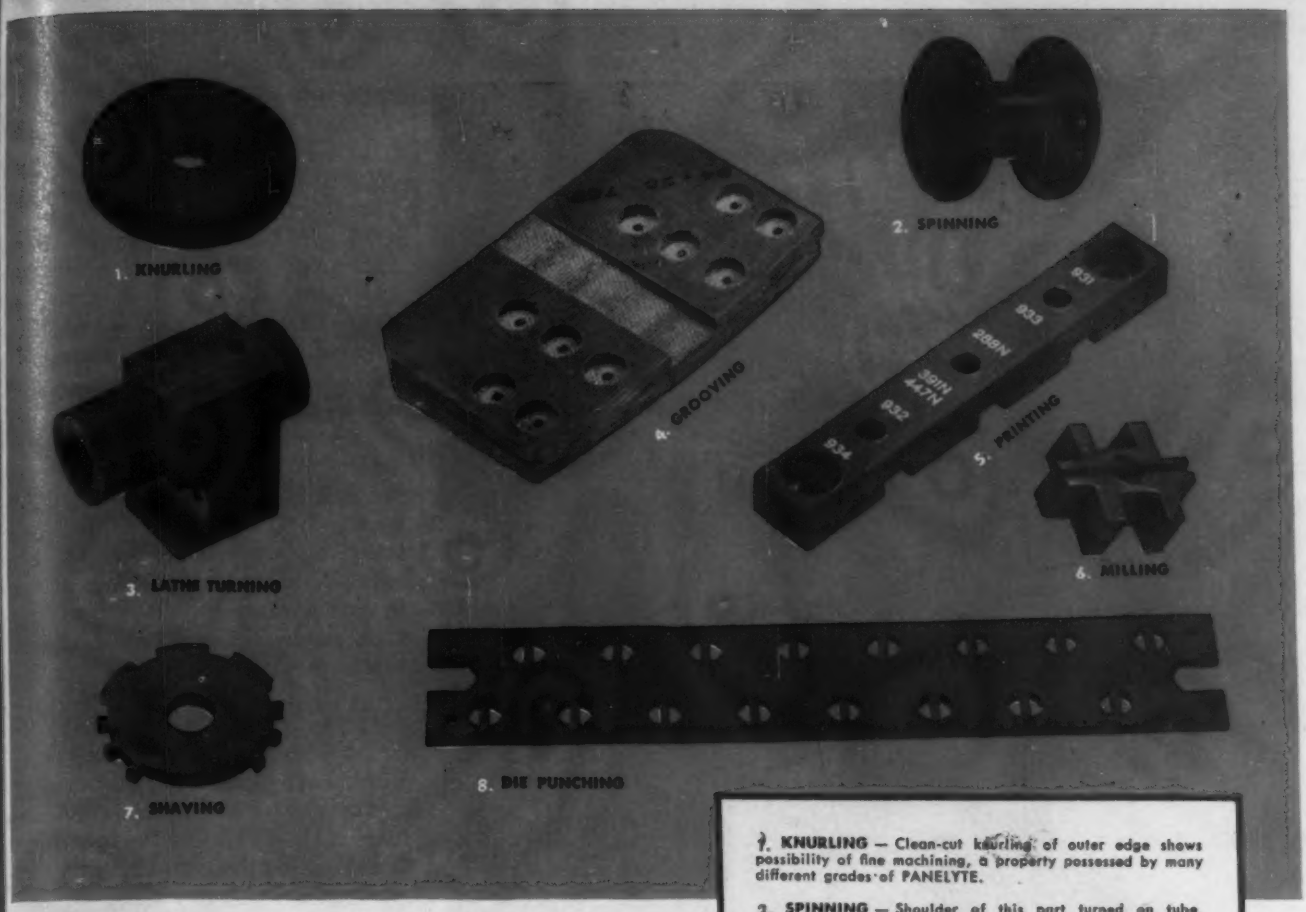
rect position, well over half of the maximum available signal has already been applied to the motor. This means that when following a straight or slightly curved line the error will usually not exceed 1/64 inch.

The control is able to reproduce, with excellent accuracy, any shape produced by a gas-cutting machine of the pantograph or two-track type. The electronic circuit and the optical system are all completely enclosed, so that they are protected from the dirt, abuse, and abrasive atmosphere.

Circuit

The electronic control circuit is shown in the diagram. Tube VT_1 is a rectifier tube which supplies d-c power for the phototube and for amplifier tubes VT_2 and VT_3. A separate rectifier supplies d-c power for the motor field.

The phototube is connected in a bridge circuit which is made up of resistors R_1, R_2, R_3 and the phototube. The resistance of the phototube varies as a function of the amount of light which it receives. Therefore, the circuit is adjusted so that when the spot of light is half on the white paper of the template and half on the black line, the signal applied to the left grid of VT_2 is equal to the signal



The Versatility of Panelyte *

the Structural Plastic, and its adaptability to the unusual or "difficult" application is evident in the random selection of parts shown above. If sheets were not thoroughly bonded and the structure homogeneous, fine cutting and close tolerance work would be impossible. PANELYTE is manufactured in Sheets, Rods, Tubes, Molded Forms and Fabricated Parts; paper, fabric, glass fibre, and asbestos base types.

Our Engineering Staff will work with you on any problem involving the use of structural laminated resinous plastics.

1. **KNURLING** — Clean-cut knurling of outer edge shows possibility of fine machining, a property possessed by many different grades of PANELYTE.

2. **SPINNING** — Shoulder of this part turned on tube. Washers punched and then spun or swedged to core.

3. **LATHE TURNING** — Irregularity of shape is no obstacle with PANELYTE. Parts are lathe turned to exact specifications.

4. **GROOVING** — Groove at taper on top surface milled, as is 1/16" groove in center of part. End milling for corners and curved contour on face.

5. **PRINTING** — Milled or drilled terminal block demonstrates clarity of identifying figures and letters printed or engraved on PANELYTE.

6. **MILLING** — Flat bed milling and drilling assure exceptionally close tolerances in this precision part of intricate design.

7. **SHAVING** — For greater accuracy than that required in standard punched parts, PANELYTE die parts are shaved to obtain essential smooth edges.

8. **DIE PUNCHING** — Straight die punching is used in the rapid, economical production of countless PANELYTE electrical parts.

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For example, the insulation tester illustrated was designed and built by EICOR engineers expressly for applying high potential stresses between certain insulated components. Such tests are made between high or low voltage windings and ground; from high to low voltage windings; from field coils to ground, and between other parts, depending on the type of the unit. *Every motor and every dynamotor,* large or small, must "take it" at a specified voltage as a routine part of production testing.

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applied to the right grid of this tube. Voltages across R_1 and R_2 are equal.

Under these conditions the output of both plates of VT_2 will be equal. Therefore, the signals applied to the grid of VT_3 will be equal. Since an equal signal appears on each grid of tube VT_3, the currents which flow in the windings of saturable reactors SR_1 and SR_2, which are connected in the plate circuit of VT_3, will be equal.

The a-c windings of saturable reactors SR_1 and SR_2 are connected in the grid circuits of VT_4 and VT_5 respectively. These tubes are thyratrons which are connected in inverse parallel, so that when VT_4 is allowed to conduct current, the current flows from the a-c line up through the motor armature circuit and back into the top a-c line. If VT_5 only is allowed to conduct, the current flows in the opposite direction and therefore, flows downward through the motor armature. D-c may be obtained from the a-c line and the motor may be driven in either direction by turning on either VT_4 or VT_5.

If both VT_4 and VT_5 are turned on by the same amount, the current through the armature of the motor will be a-c and the motor will not rotate. If VT_4 is allowed to pass slightly more current than VT_5 the result will be a slight d-c component of current in the armature circuit. Therefore, the motor would revolve slowly in one direction.

The amount of current which is allowed to pass by the thyratron tube is a function of the direct current in the windings of saturable reactors SR_1 and SR_2. When the current in the d-c winding of SR_1 (which is in the plate circuit of VT_3) is increased, the amount of current which VT_4 is allowed to pass is increased by phase-shifting of the thyratron. If the direct current through SR_1 and SR_2 is the same, then thyratrons VT_4 and VT_5 will both conduct the same amount of current and the steering motor will not rotate.

The net result is that if the voltage across R_1 is equal to the voltage across R_2 (that is, the spot is centered on the edge of the line), then thyratron VT_4 will conduct the same amount of current as thyratron VT_5. Under these conditions the motor will not rotate and the control will continue to follow along the line in the same direction.

If the spot should tend to move

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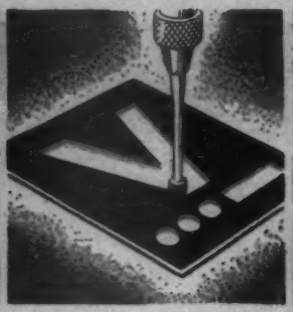
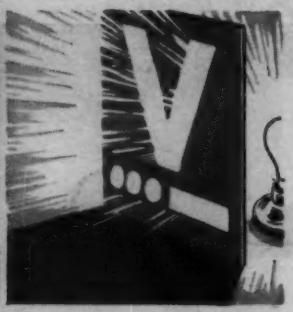
GRAPHIC-RIGID Printed wiring diagrams, charts, etc. permanently bonded under a plastic surface. Use: large-scale production at low unit cost.



ENGRAVING Sandwich type material—colored surface with contrasting core, for engraving or sandblasting. Use: individual or small-scale production of dials and panels.



TRANSLUCENT Laminated plastic sheet for rear illumination. Also made with opaque surface and in Graphic type. Use: instrument and radio dials or panels.

GRAPHIC-FLUORESCENT Luminescent compounds — permanently bonded under surface — fluoresce under ultra-violet light. Use: dials and instrument panels for black-out.

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towards the white paper, the resistance of the phototube will tend to decrease. This will increase the voltage across resistor R_3 and consequently will cause SR_3 to pass more direct current, and VT_3 to pass more current through the motor armature. This will result in rotating the steering motor in such a direction that the spot returns to the position where it is centered on the edge of the line.

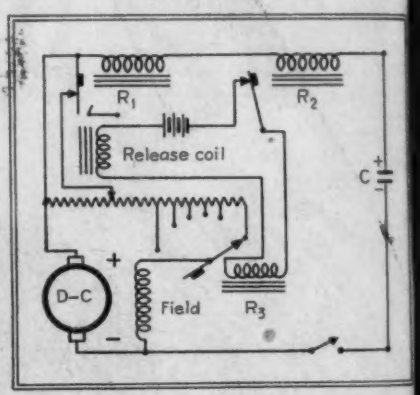
• • •

Automatic Forming of Capacitors

By SIDNEY FISHBERG

Chief Engineer
Cosmic Radio Corp.

IN THE MANUFACTURE of electrolytic capacitors, the aging process calls for the application of increasing steps of voltage to the capacitors, allowing the current at each voltage step to drop to a specified minimum value before applying the next increment of voltage. Variations in the characteristics of different lots of capacitors, variations in ambient conditions, and the need to age each lot as quickly as possible, make the use of a fixed program of voltage increments undesirable. A circuit is presented herewith which carries out the aging process automatically in the shortest possible time, thus dispensing with the need for an operator.



Control circuit for production forming of electrolytic capacitors by automatically increasing the applied voltage to parallel capacitors C as current decreases

Referring to the diagram, relay R_1 is a mechanically latched, electrically released type which will open at the maximum permissible current flowing through the capacitors. Relay R_2 is a normally closed type which is released when the current drops to

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In 8½ years, equipment designers have called for RCA metal electron tubes to the tune of over 100 million. Metal tubes — whose development was declared by Electronics magazine (April, 1935) to be "the most radical design change since the days of the Fleming valve" — have become an industry favorite.

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If you would like the help of RCA electronics engineers in connection with your tube application problems, write, outlining your problem, to Radio Corporation of America, Commercial Engineering Section, 528 South Fifth Street, Harrison, New Jersey.

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3. **SHORT LEADS** — make metal tubes suitable for high-frequency applications.
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5. **OCTAL BASE** — provides self-aligning feature and generous pin-contact area.
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7. **LOW OVERALL COST** — results from simplification of equipment design, wide acceptance, and high production.
8. **WIDE SELECTION** — is afforded by well-diversified metal-tube types to meet various equipment-design requirements.
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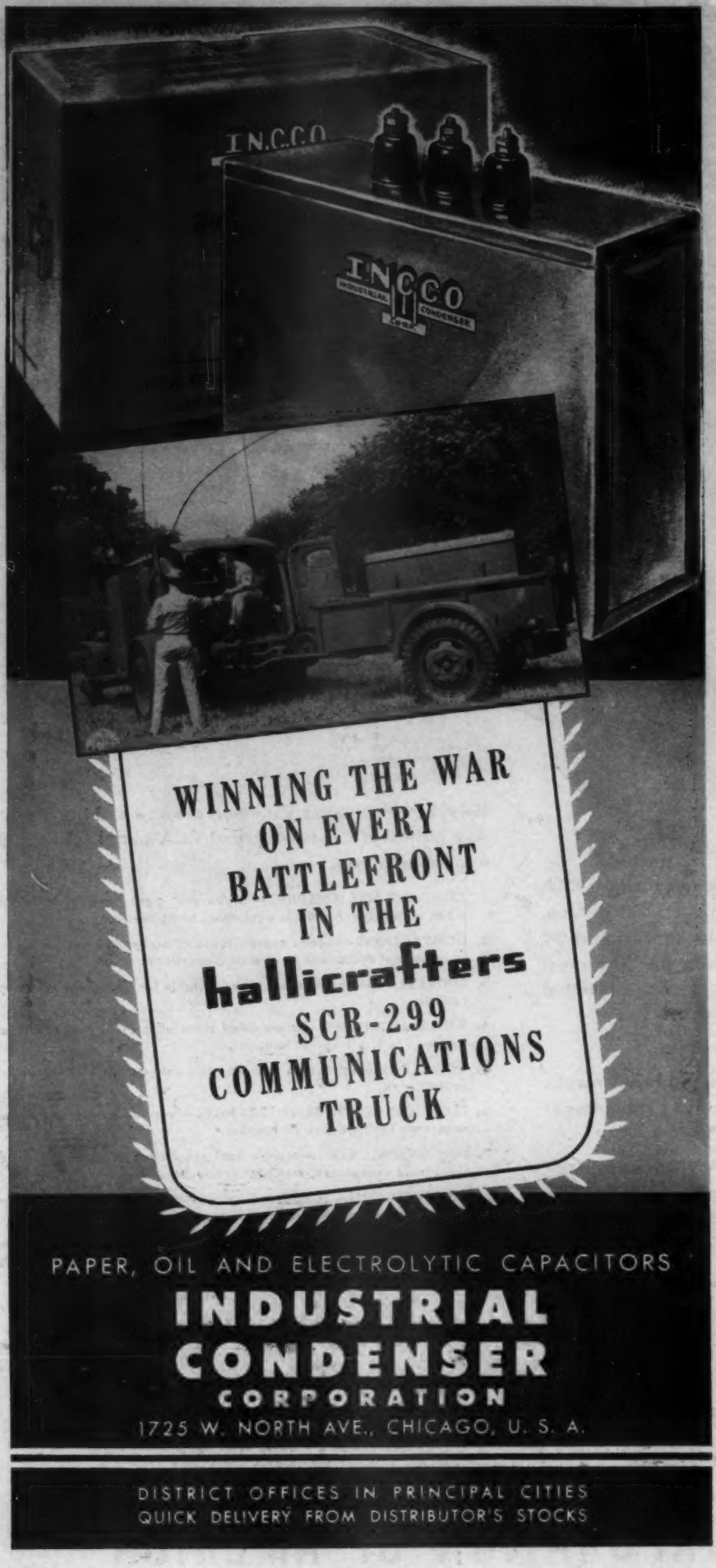

the desired minimum value. Relay R_3 is a stepping relay which controls the amount of resistance in the field of the generator.

When the switch to the capacitor load is closed, current from the generator will flow through the coils of R_1 and R_2 into the capacitors. When the current reaches the maximum permissible value, R_1 will latch open, thus adding resistance to the field of the generator and holding its voltage to a maximum intermediate limit. As the capacitors age down, the current through them decreases, and when it falls to a specified minimum value, relay R_3 closes. This unlatches R_1 and advances R_3 one step, which increases the aging generator voltage to the next higher setting. The current then increases and the cycle repeats itself.

When the voltage has reached the maximum desired value, the capacitors will float across the line indefinitely. If desired, a precision voltage relay can be connected across the line to sound an alarm and/or shut off the equipment when the aging cycle has been completed.

• • •

Electronic Flaw Detector for Metal Tubing

A NEW HIGH-FREQUENCY electronic flaw detector permits production-line detection of longitudinal cracks and seams in nonmagnetic metal tubing. The instrument detects and locates imperfections one-half inch long, ten mils wide, and one-third of the wall thickness in depth, even though they are on the inside of the tubing and do not appear on either surface.

The tubing to be tested is fed through a coil box whose coils are arranged so that they surround the tubing. After the circuit constants for the particular size of tubing be-

Production testing of nonmagnetic metal tubing for cracks and seams is provided by this G-E electronic instrument. The tubing is inserted in the coil box at the left

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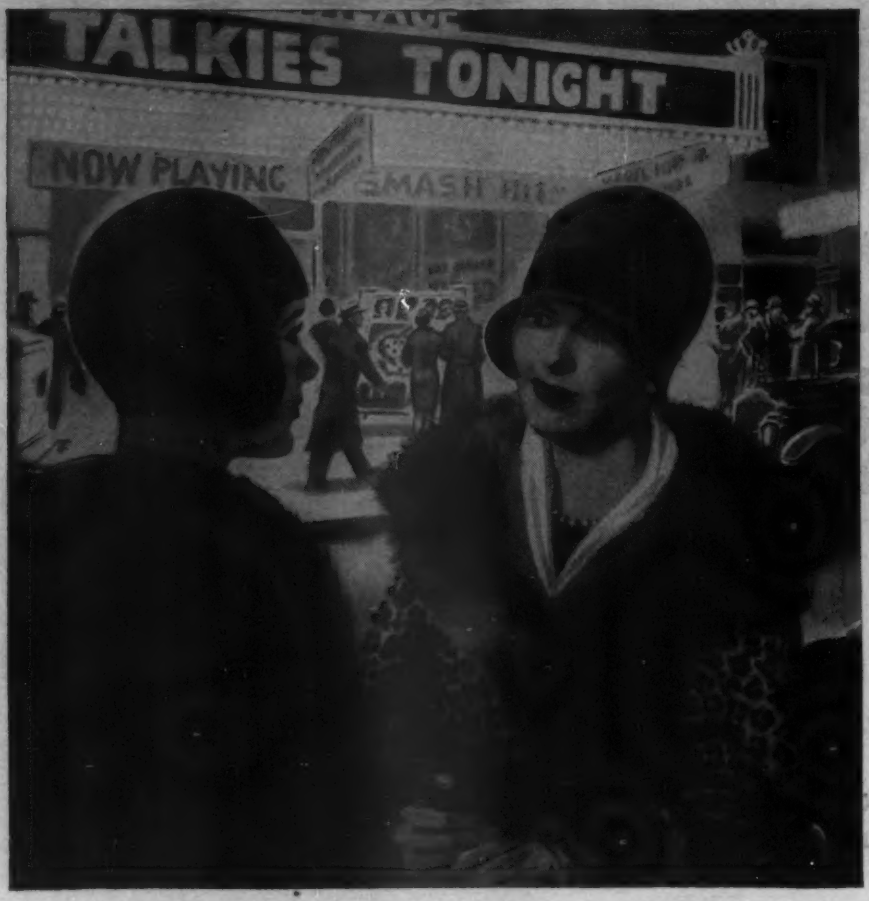

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ing tested are set by means of selector switches located on the panel of a control unit, power is applied to the coils so that eddy currents are induced in the tubing. A flaw in the tubing causes changes in these eddy currents. An electronic circuit in the control unit detects these changes and energizes a signal relay, indicating the existence and location of the flaw. The detector consists of a standard control unit, shown in the photograph, and a coil box which accommodates any one specific size of round, straight tubing of uniform outside diameter from one-quarter to two inches, inclusive. Other coil boxes are available from the Special Products Division of General Electric to accommodate any size tubing within the dimensions specified.

• • •

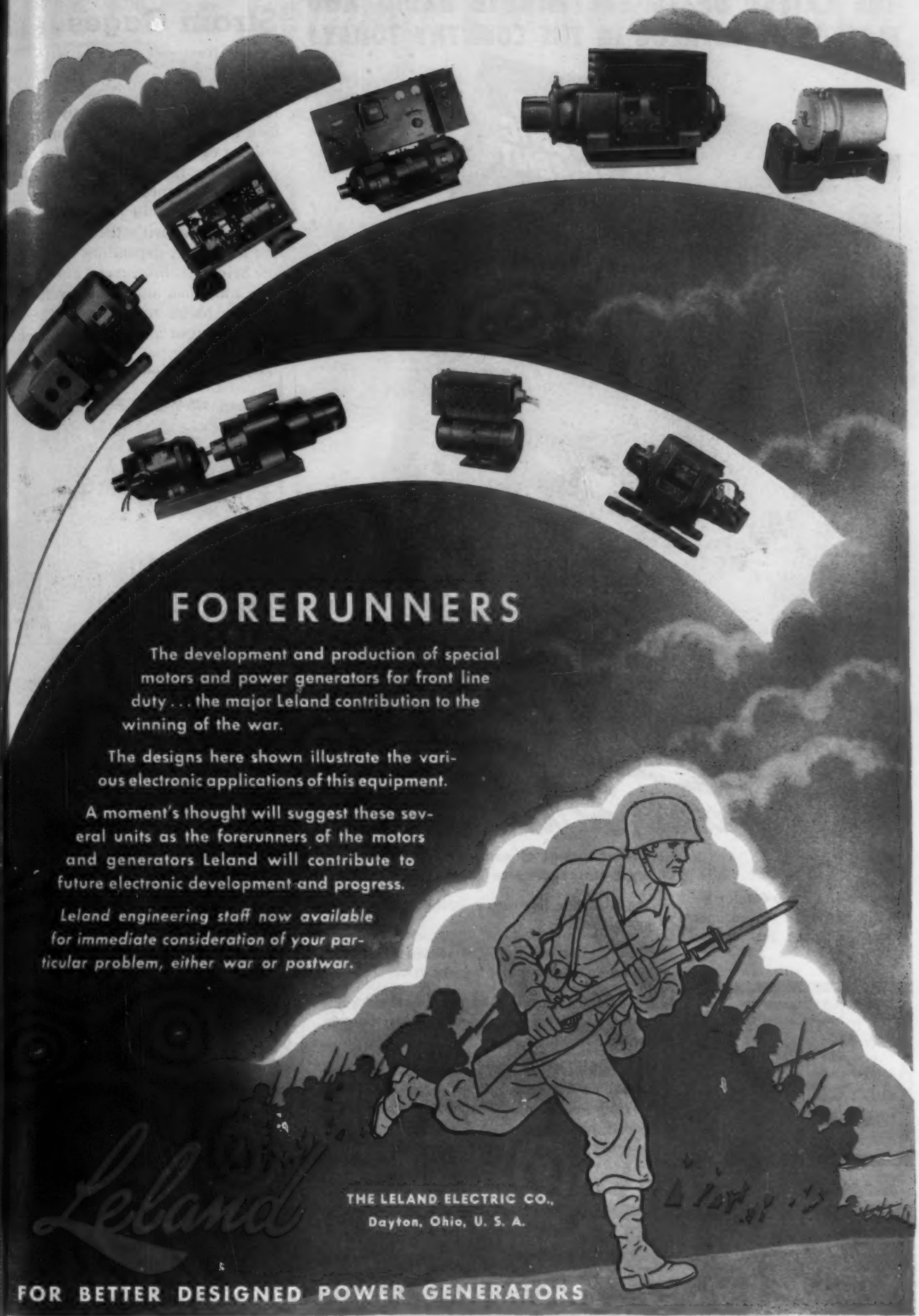
X-Rays Check Connections

AN X-RAY UNIT being used in a large industrial plant has helped reduce rejections, originally as high as 75 percent, to an average of 4 percent. The plant uses a Kelley-Koett x-ray unit for fluoroscopy and radiography to check soldered wire connections within a metal tube. The unit examines 48 connections at a time. The cost of fluoroscoping is negligible and requires no darkroom, films, or chemicals.

• • •

D-F LOOPS FOR WAR

Small radio direction finder loops for ships serving in the war effort are undergoing final assembly in the New York plant of Radiomarine Corp. of America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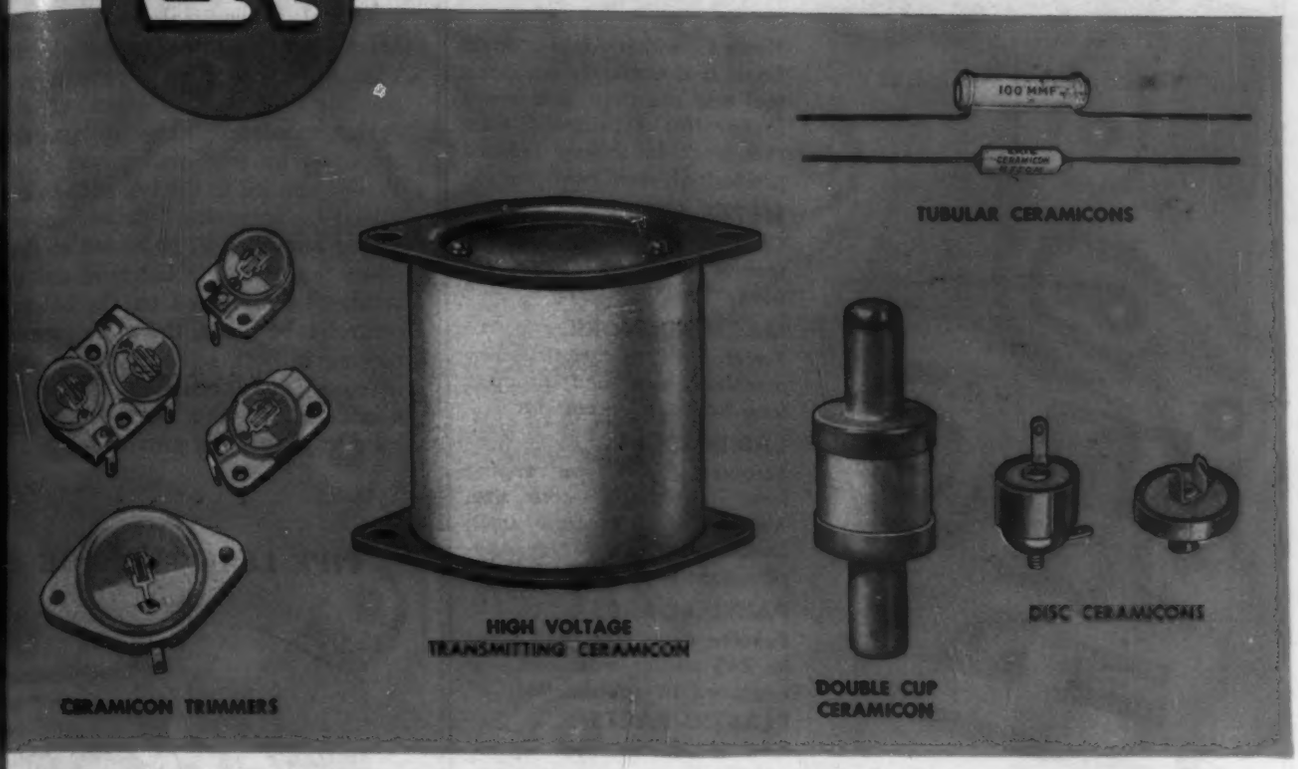
FIRSTS in Ceramic Condenser Design

by Erie Resistor



HERE are illustrated five types of ceramic condensers that are playing a vital part in today's wartime electronic apparatus and that will greatly effect the functioning of future electronics. Each is built around a basic design first created by Erie Resistor.

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For obtaining relative high capacities in compact, low-loss units for high frequency applications, Erie Resistor engineers originated disc-type Ceramicons.

The original Erie double-cup design for high voltage applications has overcome many problems that formerly limited the expansion of ceramic condensers for high voltage, high KVA applications.

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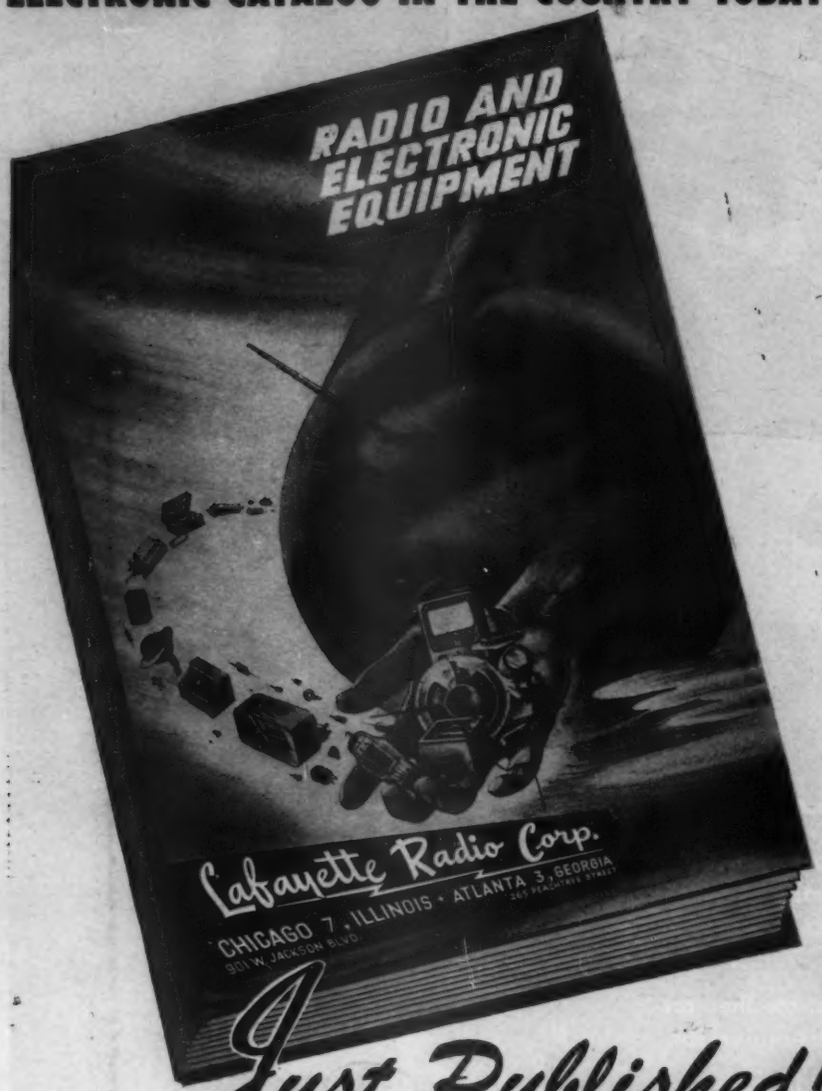
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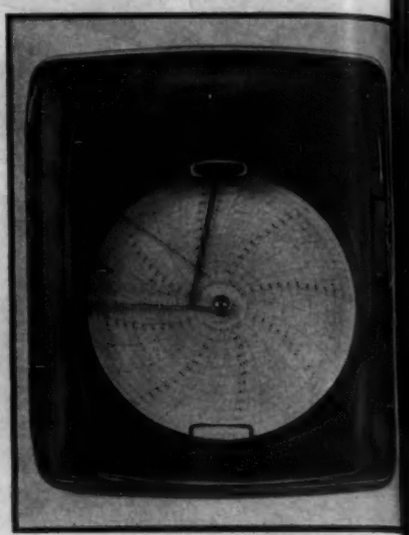
Strain Gages

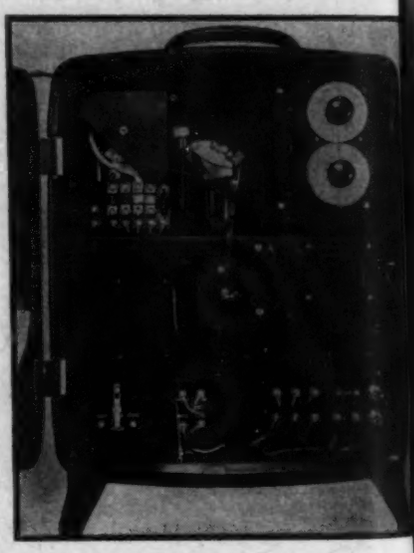
(*Continued from page 111*)

rent thus flows alternately through load resistors R_{10} and R_{12} during the halves of the voltage cycles when each plate is positive.

The unbalance voltage from the bridge is either in phase or 180 degrees out of phase with the voltage from the oscillator, depending on whether the bridge is unbalanced high or low. The amplified unbalance voltage is thus in phase with one of the tube plate voltages and in opposite phase

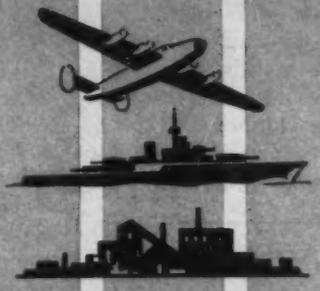


Front view of a commercial time-strain recorder employing a continuous self-balancing a-c bridge with an electronic balancing control unit



Interior of time-strain recorder, with chart plate removed. Bridge measuring circuit is in upper part of case, with electronic unit, balancing drive motor and chart drive below it

A war Hero to Consider in Your Plans for the Future



In a bomber over Berlin . . .

aboard a battleship in the far Pacific . . .

on the production lines of American factories . . .

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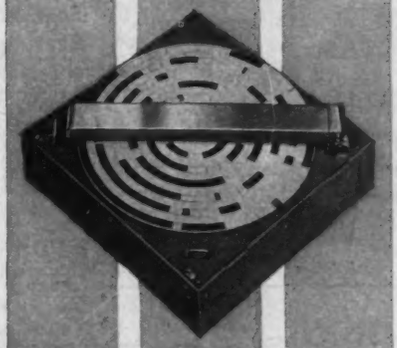

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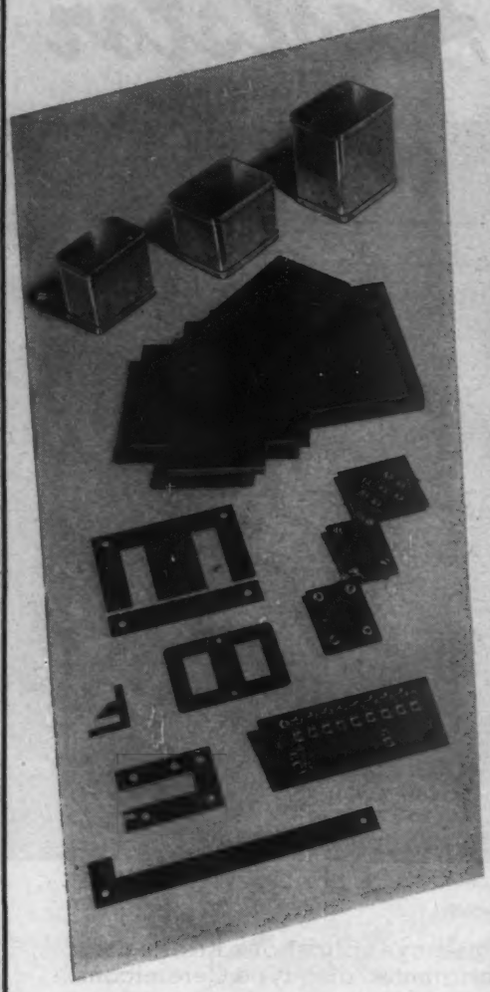
WAR WORK



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to the other. The current through and voltage drop across the plate load resistor of the element in which the grid and plate voltages are in phase will increase, and the plate current and the load voltage developed will decrease in the other half.

The balance control tube thus produces two pulsating direct voltages in the output circuits, and the difference between the voltages is proportional approximately to the unbalance voltage in the bridge circuit. This difference has a polarity depending on the direction of the bridge unbalance. These voltages are amplified by push-pull power stage V_4, and applied to the two coils in the solenoid balancing drive motor. Power amplifier V_4 is biased so that when the bridge is balanced and no voltage is impressed on the balance control tube grids, the plate current flowing in both solenoid motor coils is equal and about 40 percent of maximum. In this way continuous balancing action is provided.

• • •

PIPE LEAK LOCATOR

The vibrations caused by liquid escaping from a pipe under pressure are detected with this equipment made by Fisher Laboratories. The spot where maximum vibration takes place is a guide to the location of the leak. The lower photo shows the unit being used to trace a pipeline leak in an oil field

THE ELECTRON ART

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Engineering and Production for War is Theme of Rochester Fall Meeting

THE two-day Rochester Fall Meeting of the Institute of Radio Engineers and Radio Manufacturers Association, held at the Sagamore Hotel on November 8 and 9, drew an attendance of over 500 engineers and executives who heard presentations of papers on various aspects of radio engineering, design, and production. Because of the restrictions of secrecy, the more interesting and noteworthy of recent developments were conspicuous by their absence. Nevertheless, from the type of papers presented it was evident this year's Rochester Fall Meeting, following in the path of the 1942 meeting, was dedicated to the solution of war-time problems in the radio engineering and manufacturing fields.

Construction of High-Power Tubes

The first technical paper given was "Review of Demountable Sealed-Off Power Tubes", by I. E. Mouromtseff, who stated that both demountable and sealed-off types of power tubes made their appearance in 1923 as a result of the demand for higher outputs from individual tubes in radio transmitters. The invention of the glass-to-metal seal by William G. Housekeeper made it possible to construct sealed-off water-cooled tubes with copper anodes. Another solution was found by Prof. Holweck in France who designed a demountable vacuum tube connected to a high-speed rotary molecular pump and which was continuously exhausted during operation. Use of the Holweck molecular pump made it possible to dispense with the mercury condensation pumps and liquid air traps which were a highly objectionable part of standard equipment of radio transmitters using demountable tubes.

The life of a sealed-off tube is usually determined by the longevity of its filamentary cathode. In a demountable tube a burned-out filament strand can be replaced in a short time. Therefore unlimited life is the main advantage claimed for the demountable tubes by Holweck and other subsequent designers.

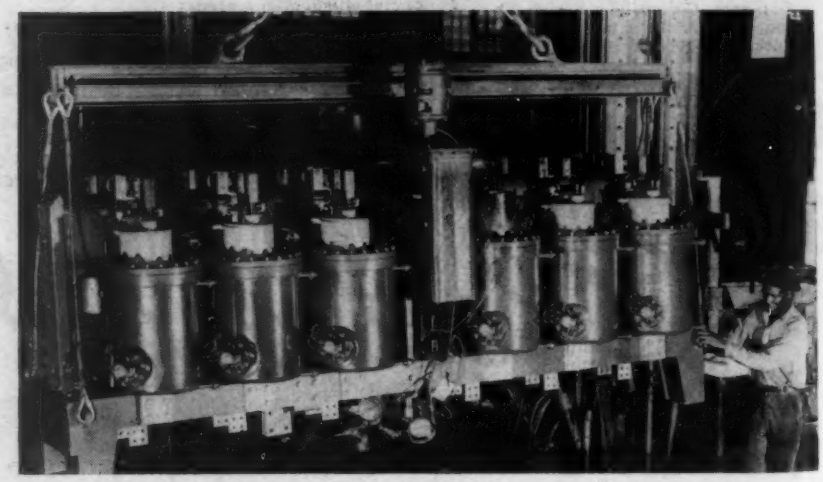
The majority of radio engineers did not favor the Holweck tubes because the rotary pumps which were required had a speed of 4500 rpm and only 0.001 inch clearance between rotor and stator. In addition, each time the tube is opened for the filament repair, the actual interruption in tube operation is much longer than the time required to replace the burned-out filament because the operating high voltage cannot be applied to the tube until the proper vacuum is reestablished. Therefore complete duplicate equipment must be maintained in operation if uninterrupted operation is of importance.

The advent of the oil vapor condensation pump invented by Mr. Burch in England promoted the cause of demountable tubes. Using the new pumps the Metropolitan-Vickers Company immediately built a 500-kw tube for a British Post Office radio station. It was followed by several types with lower outputs. In this country the oil vapor pumps, improved through the work of Dr. K. C. D. Hickman (who incidentally delivered one of the papers at the Fall Meeting) and other scientists, served as a basis for designing demountable tubes used in several scientific installations such as super-high voltage x-ray, cyclotrons, etc. In several major European countries, demountable tubes with oil vapor pumps are now in use in a few radio transmitters and also in some industrial in-

ANNUAL INDEX

IN THE INTEREST of saving paper, the annual editorial index to the issues of 1943, ordinarily published in this December issue, will be printed separately and is available free of cost to those who wish it. Write the Editorial Department, Electronics, McGraw-Hill Publishing Co., 330 West 42 St., New York 18, N. Y.

ELECTRONIC RECTIFIERS FOR KAISER MILL



This 1500-kw mercury arc rectifier is being lowered into a shipping cradle at a General Electric plant for shipment to a new Kaiser steel mill at Fontana, Calif., where it will convert a-c power to d-c power for auxiliary motors

The Model "U" shown above is 12" in diameter and rated at 1000 watts. The Model "L" is 4" in diameter and rated at 150 watts. Other models in this series of larger units are 10", 8", 6" and 5" in diameter and rated at 750, 500, 300 and 225 watts respectively. These rheostats handle tough applications with ease. They provide permanently smooth, close, trouble-free control on big jobs. Made in single or tandem assemblies, in straight or tapered winding, from 25 watts to 1000 watts.

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stallations, mainly in metallurgical applications.

A review of the use of sealed-off tubes shows that tubes with power outputs of from 100 kw up to 350 kw were designed for radio applications in the '30s by several manufacturing concerns both in this country and in Europe. Their life expectancy is up to 10,000 hours instead of the 2000 to 3000 hours originally obtained with smaller tubes. This makes the competition more difficult for the demountable type. It is believed that demountable tubes have more chance for adoption in industrial projects, in which the power output required from individual tubes may be greater than that which can be obtained from a sealed-off tube of practical design, i.e., greater than 400 or 500 kw. The application of indirectly heated cathodes in high-output tubes, similar to the one used in the 350-kw Telefunken tube, is believed probable in the future. A semi-demountable design of the medium size tubes was suggested.

Crystal Production Movies

A sound film in Kodachrome entitled "Crystals Go To War" portrayed the various manufacturing, inspection and test operations through which the raw Brazilian quartz must pass on its way to become the high-precision frequency-stable resonators which are in heavy current demand. The film was produced by and showed the manufacturing operations employed in Reeves Sound Laboratories of New York City.

I-F Transformers for F-M Sets

William H. Parker Jr. of the Stromberg-Carlson Telephone Manufacturing Company aroused interest with a paper, "The Design of I-F Transformers for F-M Receivers." In this paper it was shown that, because of the severe selectivity requirements imposed by the f-m band between 42 and 50 Mc, the superheterodyne receiver has been the only satisfactory type so far developed. Consequently, all the problems of spurious response, gain, selectivity, and stability which have faced the designer of a-m equipment used in broadcast and short-wave bands, must likewise be faced by the designers of f-m receivers.

With increasing popularity of frequency modulation, resulting in more and more transmitters in close proximity and laying down strong local fields, the use of high intermediate frequencies becomes mandatory, if spurious responses are to be minimized. However, higher intermediate frequencies make difficult the realization of satisfactory gain and stability. Hence, the design engineer is forced to compromise on some frequency which will result in acceptable gain and stability with the minimum of spurious responses. With better components and improved technique, desired values of gain and circuit stability can be obtained at higher frequency with consequent reduction in spurious responses.

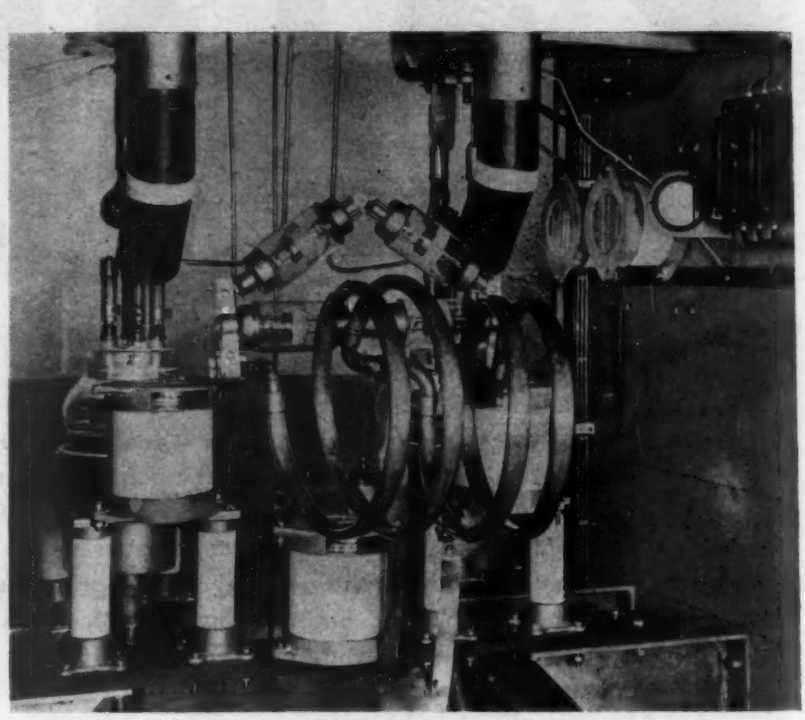
Quantitive and comparative data of the characteristics of a number of frequencies between 1700 kc and 16 Mc were presented by Mr. Parker as an aid to electronic engineers in the development of future i-f amplifier systems.

Survey of 28-Volt Tubes

A discussion, "28-Volt Operation of Radio Tubes", was given by Walter R. Jones of Sylvania Electric Products Inc. Considerable interest in the operation of radio equipment directly from batteries for airplanes has arisen since the introduction of the Sylvania type 28D7 power output tube, consisting of two beam tetrodes in one envelope with both control grids and both plates brought out to separate socket terminals. The two units may be connected as cascade amplifiers, as a push-pull amplifier, or the two sections may be operated in parallel. With this tube it is possible to obtain power output of 200 milliwatts under resistance-coupled drive conditions. When the tube is fed by means of a transformer in its grid circuit, a power output of 750 milliwatts can be obtained.

The introduction of the type 28D7 tube opened the way for battery operation, and it became desirable to learn if standard receiving tubes would give reasonable performance with 28-volt supply or if a new line of tubes would be necessary to produce equipment capable of giving satisfactory performance at this low

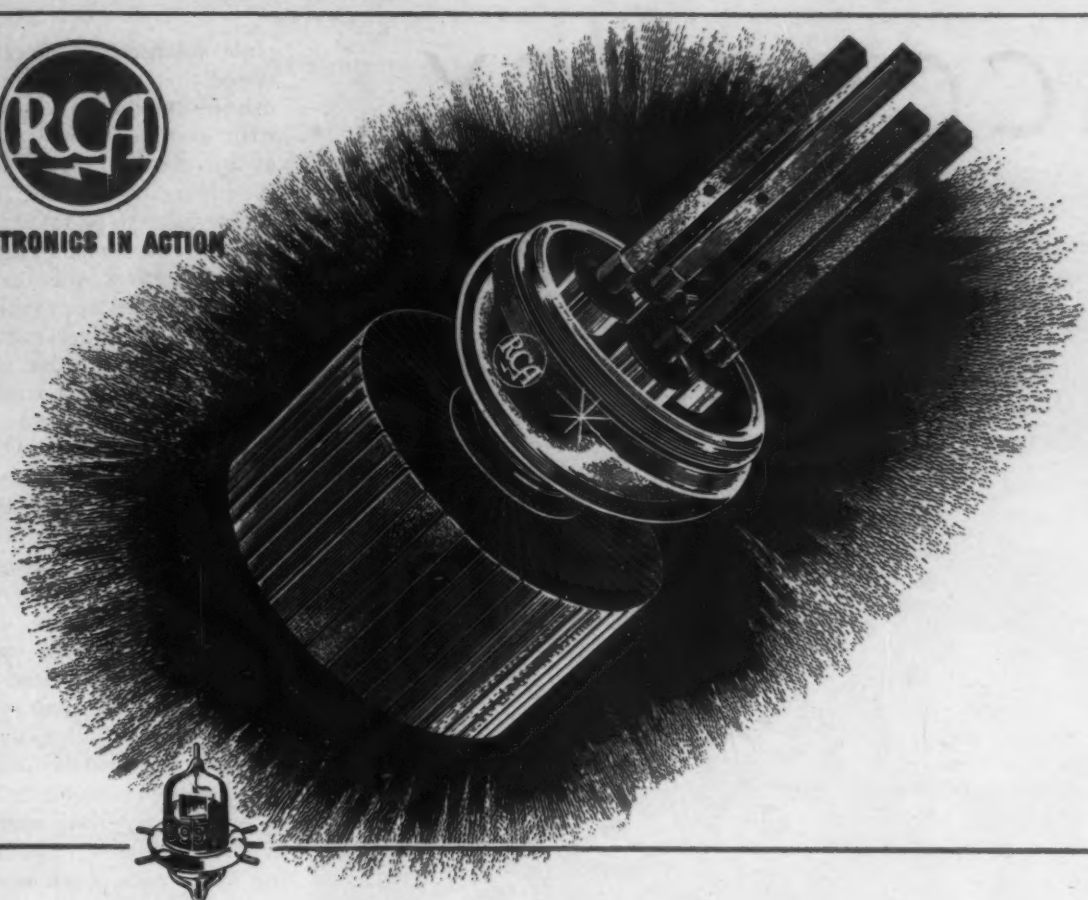
VHF DIELECTRIC HEATING



Nonconducting materials are given a dielectric heating test with this high-frequency generator at Westinghouse. Fixed vacuum capacitors are connected in the tank circuit, while ceramic-encased mica capacitors are used for bypassing. The thin white posts are ceramic standoff insulators. Coupling to the load is accomplished by the thin metal bands that lead off the bottom of the photograph; these connect to a concentric line

RCA

ELECTRONICS IN ACTION



The Strangest Radio Program

THERE'S a new radio program coming. You won't hear it! You'll *live* it. You and your children. In a new world—the world of *electronics*.

Electronics is radio — but it is also television, the "electric eye," radio-frequency heating, talking pictures. Each of these is electronics because all are basically dependent upon control of electrons by means of *electron tubes*—tubes such as are used in your radio and in the broadcasting stations.

Electronic devices, equipped with electron tubes of proper design, can perform a great variety of tasks. They can control machines and processes. Operate traffic, fire-alarm and other signal systems. Protect factory workers from accidents. Provide quick, mobile police communications. Detect and trap criminals. Sort fruit, nuts, vegetables. Weld, solder, seal, sew, weigh, measure, gauge. Fill bottles. Ease pain, treat disease. Preserve foods. Guide and land airplanes. Spot submarines. Aim and fire guns. Even keep an eye on the baby—literally!

All these jobs can be done electronically — and in almost every case, *automatically*. And electronics, via electron tubes, is going to do immensely *more* after the war. Remember that the fundamental element in *any* electronic device of any *kind* is the electron tube; and that RCA is the fountainhead of modern electron tube development.

RCA engineers in RCA laboratories and in the field are continually developing electron tube improvements of primary importance to the designers of electron equipment. To a greater degree than any other manufacturer, RCA has solved the problem of turning out in quantity high-quality tubes expertly engineered to the requirements of the practical user. RCA welcomes inquiries regarding appropriate tubes and circuits for immediate or contemplated applications. Please write us on your business letterhead. Address *Commercial Engineering Section*, RADIO CORPORATION OF AMERICA, *Harrison, New Jersey.*

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ACCURACY...

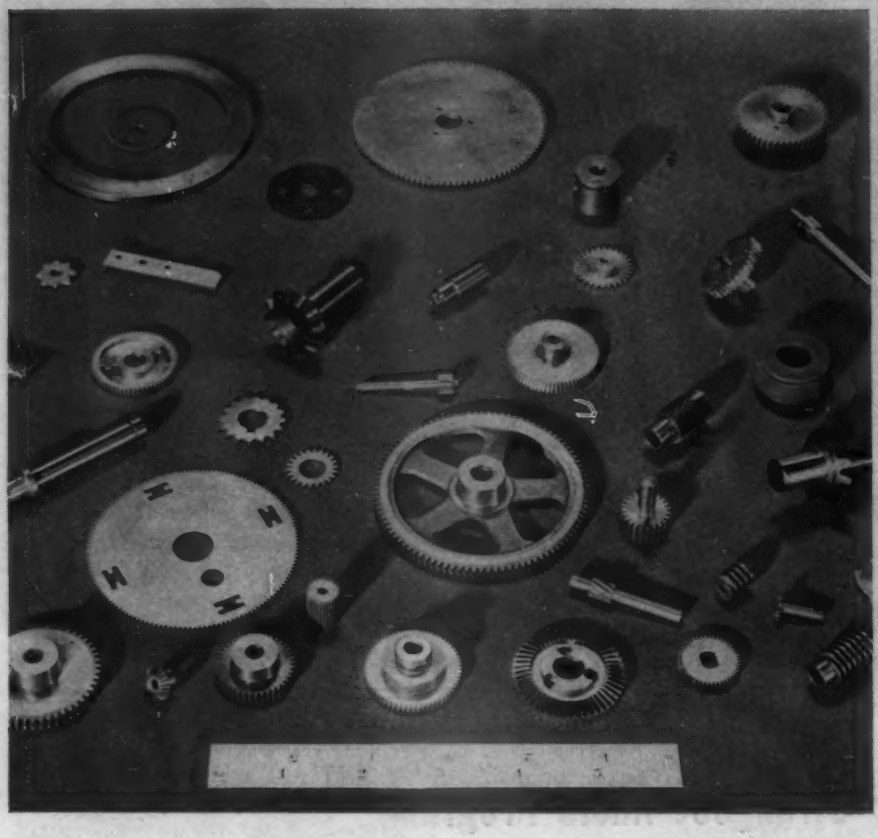

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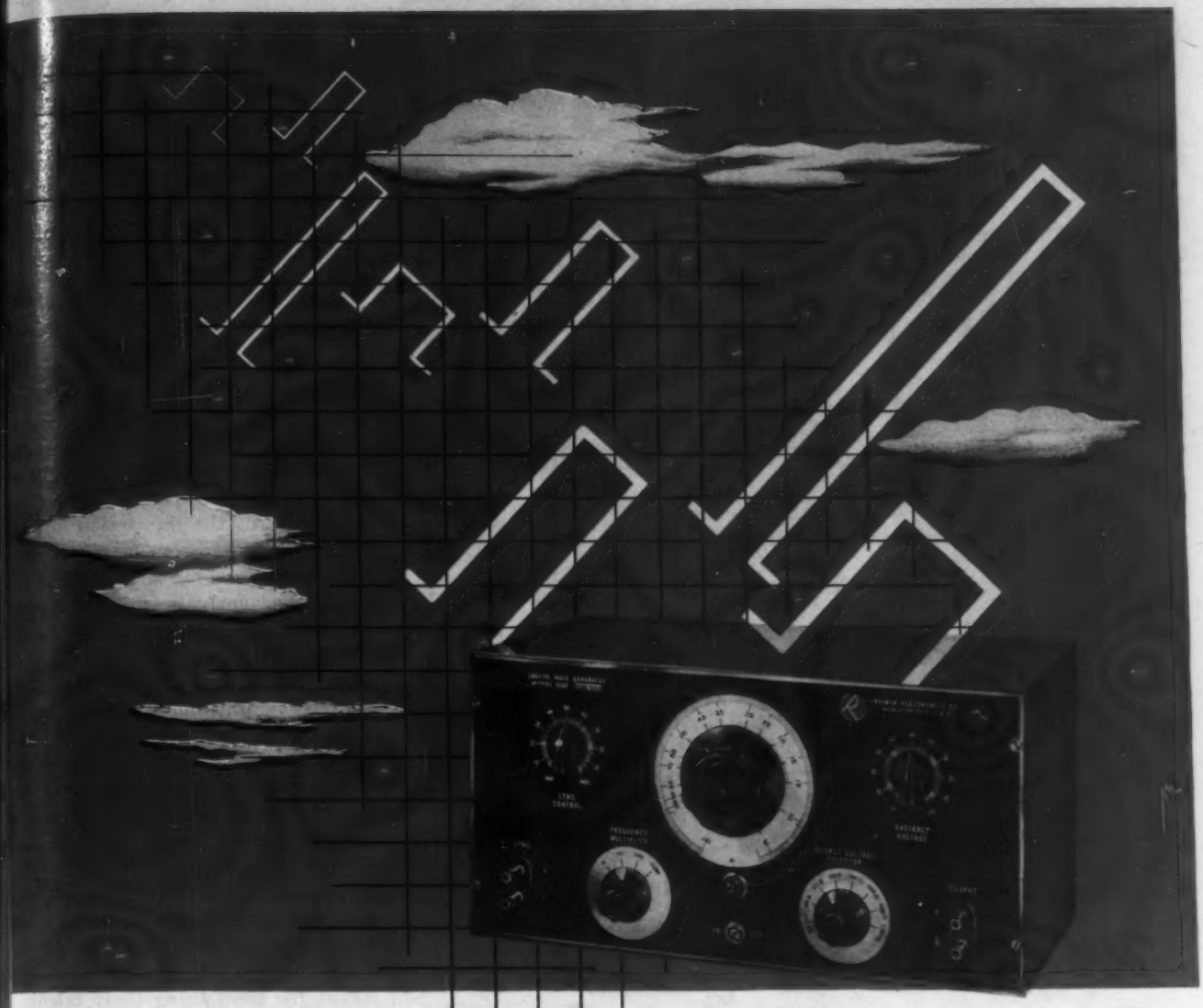
plate voltage. An investigation disclosed that standard receiving tubes may be employed quite satisfactorily with seemingly remarkable results at low plate voltages. Especially at the higher frequencies, input loading effects have to be taken into account and provision must be made to reduce this effect as much as possible. Furthermore, the operating condition of tubes under rated conditions does not always prove an indication of the performance which might be expected, when the tube is operated at reduced plate voltage. Those tubes having the highest transconductance when operated with a 250-volt plate supply will not necessarily be those tubes having the highest values of transconductance when operated with a plate voltage of 28 volts. Low-mu triodes will operate quite satisfactorily at reduced voltages although the performance of high-mu triodes under similar conditions was found to be less satisfactory.

It has been possible to build superheterodyne receivers operating up to 50 Mc and higher with tubes operating at 28 volts. Such receivers have a sensitivity comparable to that obtained with tubes operated at the normal value of 250 volts. When proper precautions are observed, considerable savings in set and motor-generator equipment can be realized by the application of tubes under 28-volt operating conditions.

Design of Vacuum Capacitors

George H. Floyd of General Electric described the properties, characteristics, and uses of a comparatively new vacuum capacitor of rugged construction, manufactured in a manner such as to make use of the technique of glass tube operation. The vacuum capacitors are suitable for use in high-voltage circuits where fixed values of capacitance may be applied. By operating these units in series or in parallel, it is possible to increase the total capacitance or the operating voltage at which the units are operated. A typical vacuum capacitor has a break-down voltage of 6000 volts and a capacitance of 50 $\mu\mu$f. The capacitors are constructed by sealing two electrodes into a glass tube, which acts not only as a protective seal to keep dust, humidity and foreign particles out of the dielectric but which also gives the unit mechanical strength. This design provides a



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Other noteworthy features include: a band calibrated frequency scale (10 to more than 100 cycles), synchronization control, variable output voltage controllable from 0 to 20 volts, with output impedance variable from 0 to 2000 ohms, and a power supply designed to operate on 110-125 volts, 60 cycle AC. Complete, ready to operate, Model 530 costs only: $95.00.

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unit which is quite free from humidity or temperature variations.

Design considerations were discussed from the viewpoint of both the designer and the manufacturer. Capacitor formulas were given, and the equation for energy loss was derived. Operating characteristics and ratings of vacuum capacitors were considered, as were also the effects of humidity, temperature, and vibration.

Volunteer War Work of Scientists

Dr. K. C. D. Hickman of Distillation Products, Inc., Rochester, N. Y. outlined the voluntary activities of a group of Rochester engineers and scientists in a paper entitled, "Chamber of Commerce War Research Committee". At the invitation of the Rochester Chamber of Commerce, the War Research Committee was established early in 1942 to discuss research needs of the armed forces and the methods by which engineers and scientists in the Rochester industries might make direct contribution to the solution of such problems. Dr. Hickman pointed out that under present conditions there are thousands of scientists, scores in each large city, who have no means of making any direct technical contributions to the war effort. These men are pathetically eager to help. The voluntary War Research Committee offers at present the only means for harnessing their talent.

In spite of many difficulties, of which the most important appears to be lack of familiarity with problems requiring solution as a result of the real or imagined need for secrecy on any or all projects, the Rochester War Research Committee has made three contributions which are finding direct application in the armed forces. On the basis of 18 months of experience in directing the activities of the Rochester War Research Committee, Dr. Hickman suggested the following procedure for the establishment of similar committees in other municipalities:

(1) It is imperative to secure governmental blessing in order that appropriate contacts may be made and the work of the committee may be directed into useful channels.

(2) Use every legitimate device to gain war education. Invite officers from overseas to meetings rather than enlisted men, since it is assumed that officers are competent to

The vision in Television

To the research mind, day dreams are an important part of scientific achievement. *Vision* and ceaseless work on the part of RAULAND scientists and engineers, for example, brought the cathode ray tube, heart of television, to its present perfected state. As a result, television can today be projected on theatre screens with a clarity and definition comparable to that of regular film showings.

★ Modern applications of electronics are so vast in scope and require such delicate variations in size and power of the actuating tubes that the RAULAND organization devotes its facilities, not to *mass production,* but to *custom engineering* . . . producing tubes and other electronic instruments of specific design and capacity to fulfill the tasks each are called upon to do.

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BACK THE ATTACK BUY WAR BONDS

censor properly any information they may give out.

(3) Introduce themes for discussion which have been evolved in a steering committee, and foster cooperative thinking.

(4) Edit ideas before submitting them to any government agency. Bad ideas which may be submitted so discredit the organization that even the good ones may fail to receive the proper attention if editing procedure is not strictly followed.

(5) Make each sub-committee reduce its assignments to practice, preferably by making a working model of the device under consideration.

(6) Do not allow the voluntary activities of the members to encroach on their professional war efforts in the service of their employers.

(7) The secretary should keep careful notes of all discussions so that immediate government assignment of rights and post-war ownership of inventions may be arranged correctly. These notes should not contain intimate technical details.

Curves for I-F Circuit Design

A paper, "Aid in the Design of I-F Systems" by J. E. Maynard of the General Electric Co., showed that the design of an i-f system to meet specified requirements for modulation sidebands, frequency drift, accuracy of frequency setting and elimination of adjacent-channel interferences may be worked out with the assistance of selectivity charts prepared for this purpose. A graphical presentation of such a problem is shown in Fig. 1. The frequency deviation *A* includes drift, frequency set-

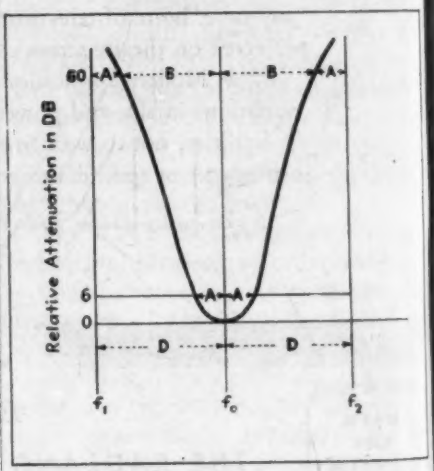

FIG. 1—Basic I-F circuit design curve

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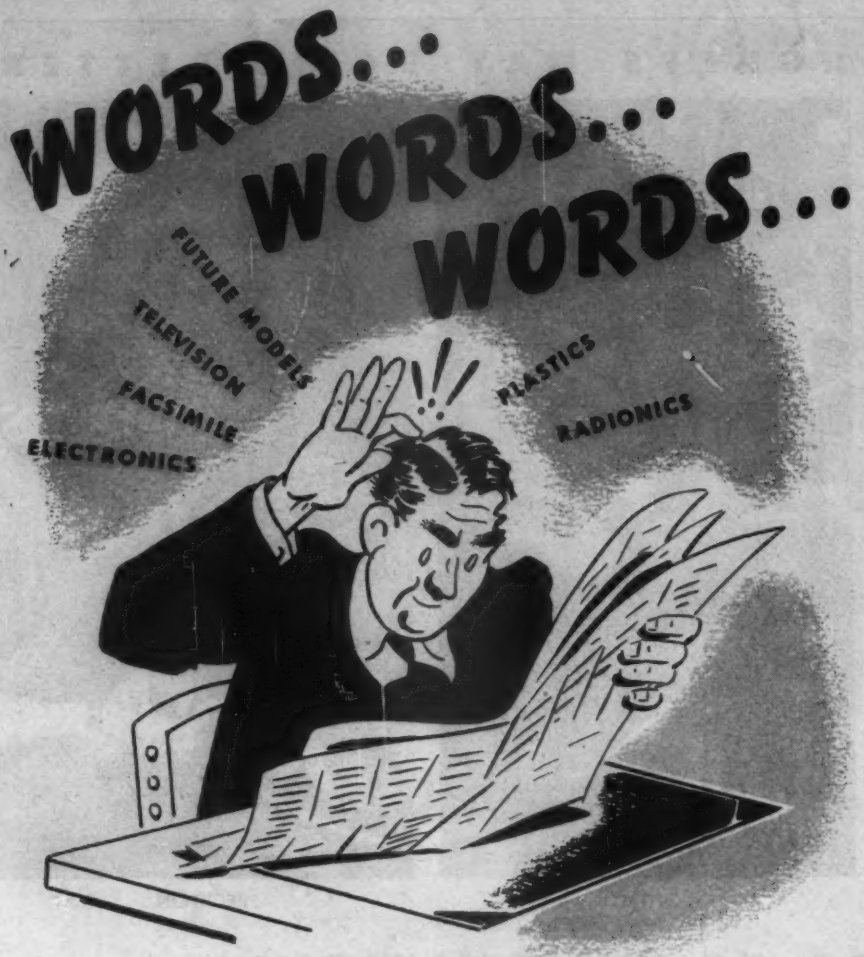

. . . What's it all about?

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ting, and modulation requirements. It is required to maintain the signal within 6 db level of resonant frequency response. The adjacent signal of frequency f_1 or f_2 is to be maintained at an attenuation of 60 db or more relative to the response at resonance. The undetermined quantity in the diagram is the frequency deviation, B, on the selectivity curve. In practice, B is related to A, and graphical means for its evaluation may be derived.

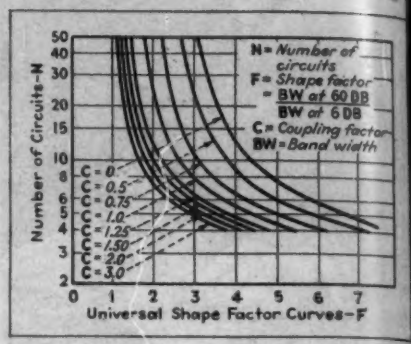
Number of Circuits-N
N = Number of circuits
F = Shape factor = BW at 60 DB / BW at 6 DB
C = Coupling factor
BW = Band width
C = 0
C = 0.5
C = 0.75
C = 1.0
C = 1.25
C = 1.50
C = 2.0
C = 3.0
Universal Shape Factor Curves-F

Fig. 2—Selectivity chart giving shape factor for i-f circuits

The ratio B/A is plotted as shape factor F in the chart of Fig. 2. This chart gives the relationship between the shape factor, F, and the number of tuned circuits in the amplifier for various proportions of critical coupling. Critical coupling is designed by the curve marked $C = 1.0$. The numbers on the curve of Fig. 2 therefore represent the percentage

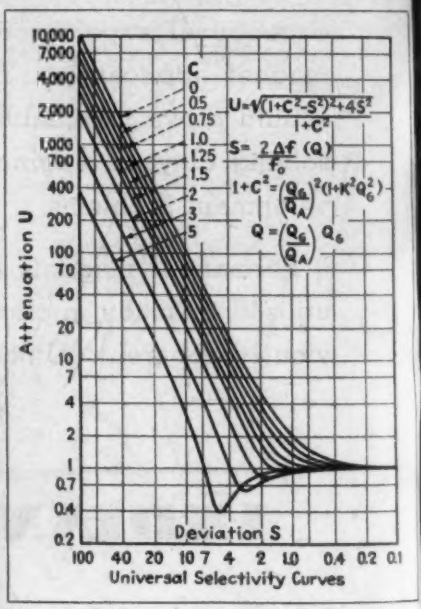

Fig. 3—Universal selectivity curve for a pair of coupled circuits

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of coupling in terms of critical coupling. Values less than unity represent undercoupling whereas values greater than unity represent coupling conditions greater than the critical value. The number of circuits, n, is the count of the number of tuned circuits, a pair of coupled circuits being counted as two circuits.

The curve of Fig. 2 was derived by Mr. P. C. Gardiner from the universal selectivity curve shown in Fig. 3. The latter curve represents the selectivity obtainable from a pair of coupled circuits. Nonsymmetry due to variations directly and inversely related to frequency have been neglected and Q is assumed to be 5 or more.

In general, good agreement with practical circuit performance is obtainable. The value of Q in primary and secondary is converted to an equivalent Q in terms of the geometric mean Q_g and the arithmetic mean Q_A. This equivalent Q then relates the selective variable S to frequency deviations in comparison with resonant frequency f_r.

Research on Ceramic Dielectrics

A paper, "Operating Characteristics of Ceramic Dielectrics with Constants over 1000" was given by R. B. Gray of Erie Resistor Corp., and covered research carried out in this field. Although the results to date have been somewhat discouraging, it is hoped that further research will show applications for these unique ceramic materials in the radio industry and elsewhere.

RMA Data Bureau Report

L. C. F. Horle described the wartime work of this organization, and traced the progress of the nomenclature for a new tube from its conception to final production. Because of secrecy requirements, many new tubes are not getting past the stage of registration and assignment of a type number, and considerable work will probably be necessary after the war to coordinate the new tubes and eliminate duplication or near duplication of types.

Captured Equipment Display

German, Italian and Japanese radio equipment placed on display by the Signal Corps attracted a great deal of attention, particularly after cabinets had been removed from

GUIDING AIRCRAFT—AmerTran Wave Filters are essential components of a number of types of navigation and communication equipment used by military and civilian aircraft.

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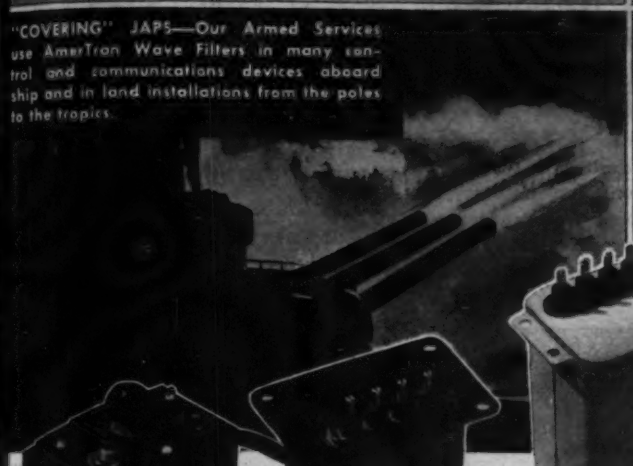
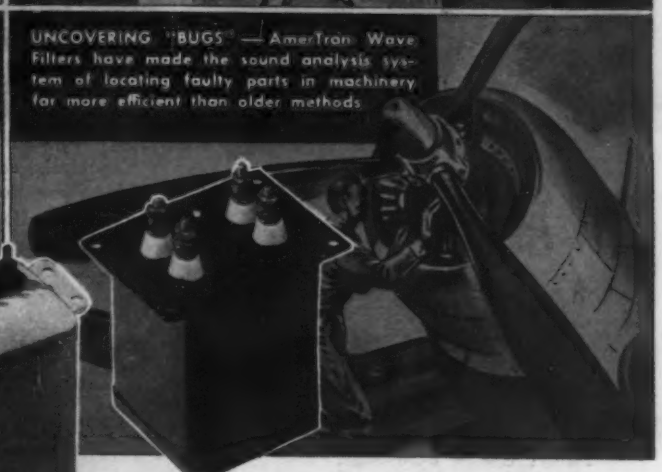


"COVERING" JAPS—Our Armed Services use AmerTran Wave Filters in many control and communications devices aboard ship and in land installations from the poles to the tropics.



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some of the units to show constr tion of chassis and components. P tos of some of this equipment shown elsewhere in this issue ELECTRONICS.

RTPB Setup

The present status of the Ra Technical Planning Board was p sented by Dr. W. R. G. Baker, RM Director of Engineering. He o lined the aims of the board, point out that certain of its committe would necessarily have to work secrecy from now on until they w ready to announce results, and e phasized that the entire post-w planning program is to be built the framework of experience gain by the highly successful NTS Chairmen and vice-chairmen RTPB panels that have been orga ized to date were announced by Baker, as follows (ch. first): 1 Spectrum Utilization—Dr. A. Goldsmith and Dr. R. H. Manso 2—Frequency Allocation—Dr. C. Jolliffe and F. M. Ryan; 3—Hig Frequency Generation—R. M. Wi and H. F. Argento; 4—Standa Broadcasting—H. S. Frazier a Burgess Dempster; 5—VHF Broa casting—G. E. Gustafson and C. Jansky; 6—Television—D. B. Smi and I. J. Karr; 7—Facsimile—J. L. Hogan and C. J. Young; 8—Rad Communication—Haraden Pratt; —Relay Systems—E. W. Engstro and Ralph Brown; 10—Radio Rang Direction and Recognition—W. Hilliard and C. G. Fick; 11—Aer nautical Radio—J. C. Franklin; —Industrial, Scientific and Medic Equipment—C. V. Aggers and H. Marvin; 13—Police, Emergenc Services—D. E. Noble and Fra Walker.

Army Communications Gear Experience

A nontechnical talk entitled "T Signal Corps Looks To The Eng neer" was given by Major James Heinz, Office of the Chief Signal O ficer, Washington, D. C. Majo Heinz traced the historical develo ment of modern radio communic tions, particularly as it is used the armed forces, and emphasized t role which engineers have played the development of this science.

The breakdown of the Unit States Army into a series of echelo or levels of organization was d scribed, and the means by which ea

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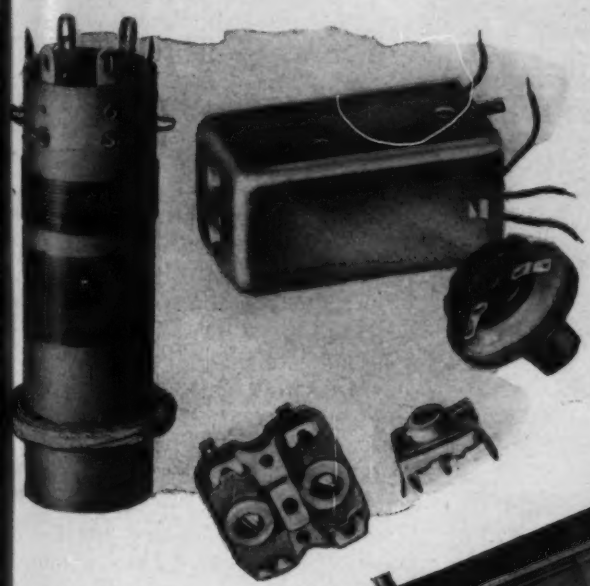

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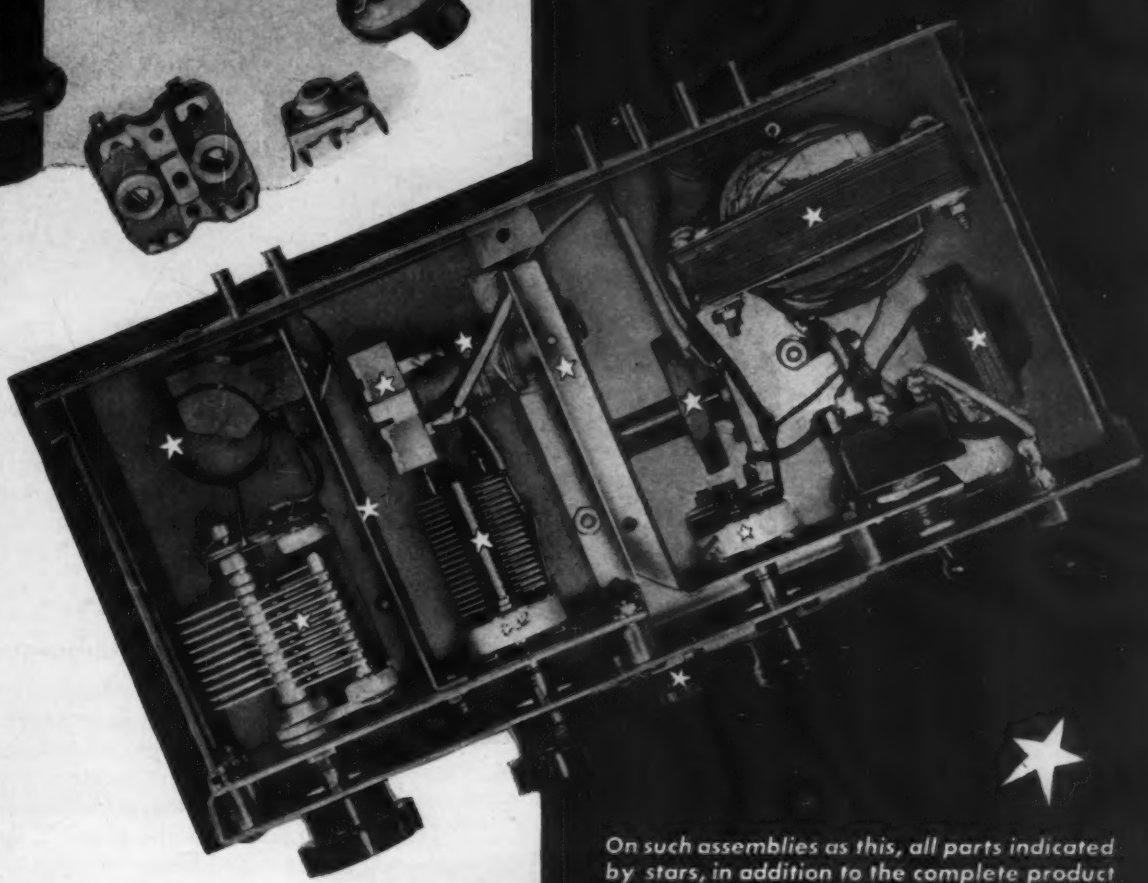

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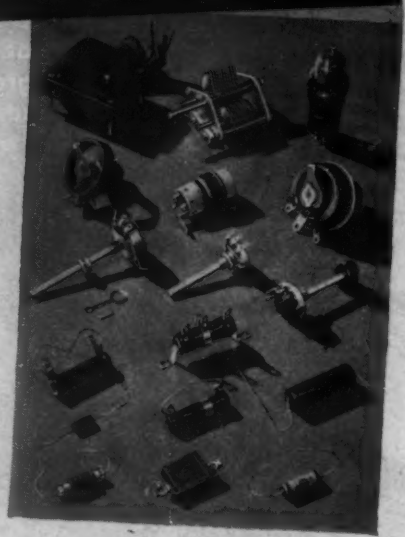

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of these maintained its communication with the lower or higher echelons was outlined. The Signal Corps, responsible for the communications of the army, now contains a personnel larger than the entire United States army during 1939.

An important distinguishing feature between the communication nets of the army and the communication systems of telephone companies or other commercial communications concerns is that emphasis is laid on having ready channels available without any thought of the economic loss factor on such lines or radio systems. The ability to get the message through is of primary importance.

An example of the flexibility of modern army communication systems is illustrated by an incident which occurred during the campaign on Bataan. Because of the terrific barrage which the Japanese were laying, it was impossible to get satisfactory observation from the American forces to direct fire effectively. American soldiers infiltrated the Japanese lines and, by means of a "walkie-talkie", directed the fire of Corregidor's guns. Thus a midget radio set made it possible to wipe out the Japanese gun emplacement harassing our troops.

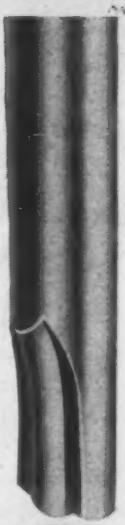
In the matter of design and construction, Major Heinz pointed out that whereas many notable improvements had been made in American communications equipment in the last few years, no substantial improvements have been made in the enemy's sets in the last four years.

• • •

Cosmic Ray Radiosonde

THE INTENSITY of cosmic rays at very high altitudes is measured by sending up a free balloon with one or more Geiger counters which transmit impulses by radio to a receiving station on the ground. Such cosmic ray radiosonde equipment must also transmit the barometric pressure at regular intervals during the flight. An instrument for this purpose is described by W. H. Pickering in the *Review of Scientific Instruments* for June, 1943. This is an improved version of a previous instrument and contains a new means of modulating the transmitter, a new receiver, and a new recorder.

One of the problems encountered with the radiosonde is the fact that



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the counting rates at high altitude must be as large as possible, and hence individual counts cannot be recorded directly, but must be scaled down electrically until a slow enough rate for a mechanical recorder is obtained. This scaling can be done at either the ground station or the transmitter. In the older model of the instrument the scaling was done at the transmitter. This has the advantage that the transmitted pulse was long enough to be distinctive and long enough to operate a simple super-regenerative receiver. However, the scaling circuits were difficult to adjust and were out of the control of the operator once the flight had started.

In the new radiosonde the scaling circuits are at the receiving station. A consequence of this is that the transmitted pulses must be so short that the probability of missing counts which are very close together is negligibly small. With counting rates of the order of 20 per second, a resolving time of 1/2000 second is necessary if only 1 percent of the counts are to be missed. In the actual transmitter the time between pulses is about twice this. Hence the experimental counting rates of 100 per minute do not need to be corrected for the resolving time of the transmitter.

Transmitter Circuits

The circuit for keying the transmitter is shown in Fig. 1. Normally there is sufficient grid bias on the oscillator tube to prevent oscillation. When a cosmic-ray impulse is received simultaneously on two Geiger counters and passed through amplifiers and the coincidence selecting

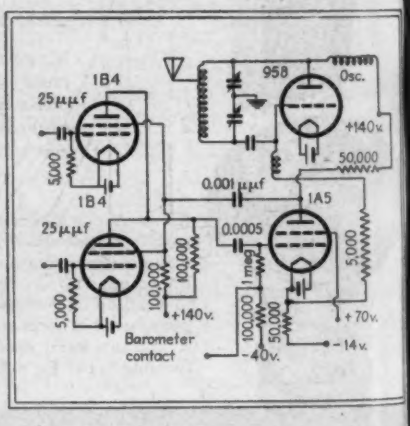

Fig. 1—The 1B4 tubes and the 1A5 form a multivibrator that acts as a coincidence selector that triggers the 958 oscillator

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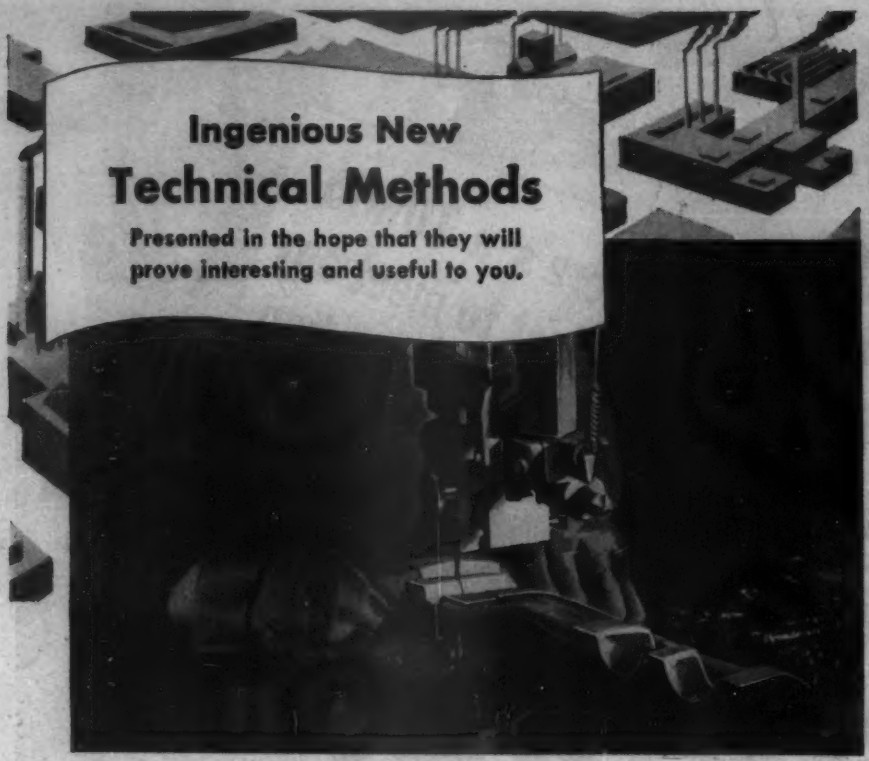

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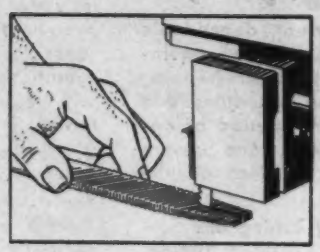
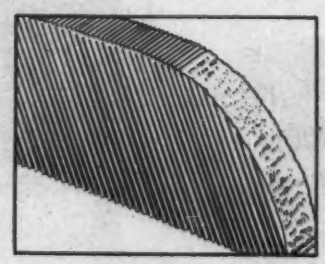


Proof of ability of new method to cut hard materials is demonstrated by operator cutting a file.



The temper of curve cut section shown above is unaffected.

X-62

circuit composed of the 1B4 tube the positive impulse at the grid of the 1A5 power tube will initiate a single cycle of oscillation in the multivibrator consisting of the 1B4 coincidence selecting tubes and the 1A5. This automatically removes the bias from the oscillator tube and a signal is radiated for the duration of the multivibrator pulse.

The Geiger counter amplifiers not shown in the diagrams, each have two stages ahead of the coincidence selecting stage. In order to have the correct polarity of pulse at the coincidence selecting stage, the counter pulse is taken from the wire of the counter. Uniformity of pulse to the coincidence selecting stage is secured by using multivibrator action around the two amplifier stages.

Barometer and temperature signals are transmitted by contact of a clock-driven arm with the indicating arms of the barometer and thermometer, thus using the Olland cycle. During the contact, as shown in Fig. 1, the bias is removed from the grid of the 1A5 power tube. Hence the multivibrator, formed by this tube and the 1B4 coincidence selecting stages, will oscillate at its natural frequency, and transmit a high-frequency audio note. At the receiver the barometer and thermometer signals will accordingly be easily distinguished from the cosmic-ray signals.

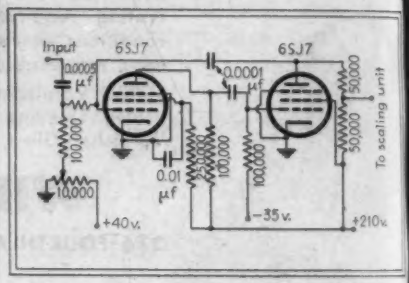


Fig. 2—The input pulse-shaping circuit of the scale-of-64 counter

The complete unit is hung in a bamboo cage for mechanical protection, and wrapped in Cellophane for thermal insulation. The transmitter is above the basket, with the lines from the balloon attached to the upper end of the antenna.

Receiver Circuit

With the transmitted pulses of the order of 10^{-4} second long, a super-regenerative receiver is useless. The

Speed Nuts IMPROVE Plastic Window Assembly

SPEED NUTS answer the problem of attaching plastic windows without danger of fracturing. They provide a spring-tension grip that frees the assembly from dead-tight fastening pressure. They also hold the plastic firmly in locked position under vibration and permit expansion and contraction of the plastic without damage. Washers are not needed as the wide bearing surface of the SPEED NUT spreads the load over a greater area and away from the screw hole. These SPEED NUTS are also applied faster—saving many manhour's time and reduce the net weight of the assembly.

In the first case illustrated, a "U" type Speed Nut snaps over plastic edges in self-retaining position. A round type Speed Nut is used in the second installation with rubber grommets in larger screw holes for additional cushion and seal. In the third method, where 2 pieces of plastic overlap, a cup-shaped Speed Nut is used with a mated Speed Nut washer—both formed to extend the load farther from the screw hole.

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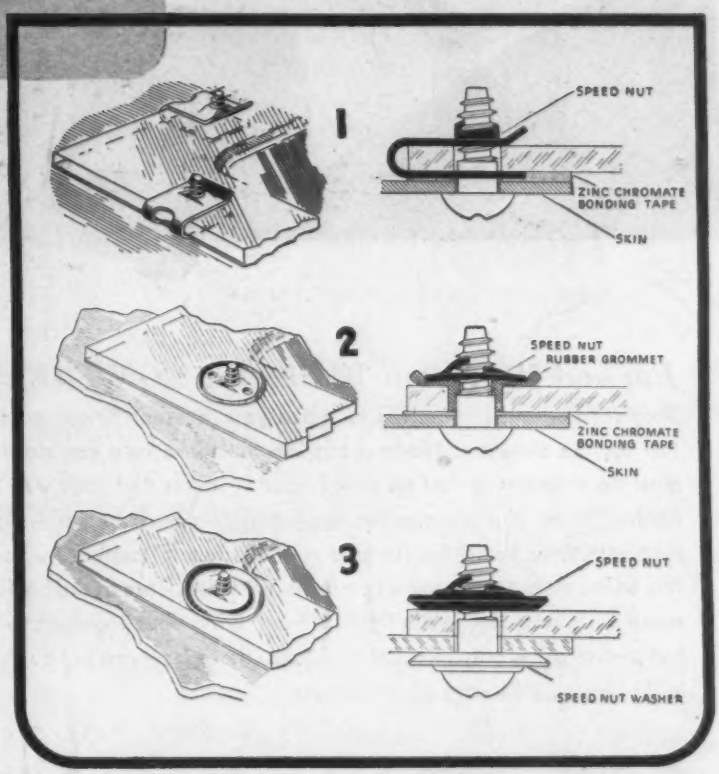

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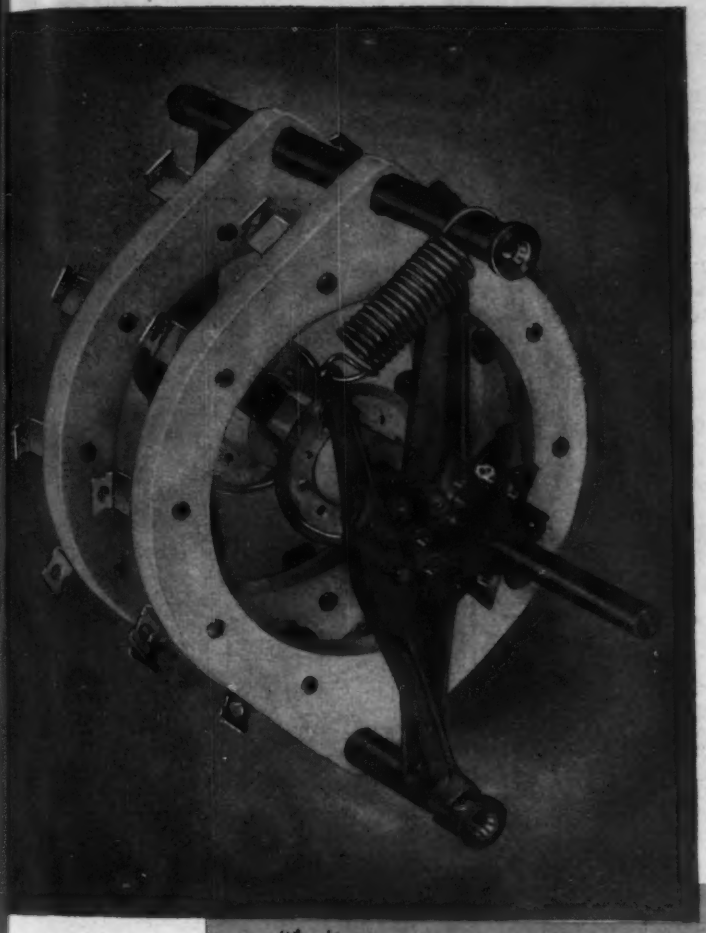


MECHANICAL RUGGEDNESS is not enough for today's switch applications. That is why all conducting paths in STERLING SWITCHES are made of *pure silver*. So permanent are the electrical characteristics of this newest development of Communication Products that the "electrical life" of the STERLING SWITCHES is as long as their mechanical life.

C-P research revealed other advantages in the use of pure silver. Silver, even the oxide of which is an excellent conductor, makes unnecessary high spring pressures to cut the insulating oxides that are formed on the metal contacts of conventional switches. This reduction in friction permits multiple-gang assemblies with no loss in ease of operation.

With an almost infinite variety of wiring designs made possible with the many rotor and detent styles available, it is more than likely that STERLING SWITCHES offer the solution to your switch and switch gear arrangements, manual or machine operated. Available in two standard sizes, 86S and 88S. Send for complete information.

Illustrated, Type 88S—2-Gang Sterling Switch

SURE, "'PHONE BOOTHS" WILL HAVE FRESH AIR...

When the war is over, what a boon to this country radio telephony is going to be! In bridge building, for example, a construction foreman will be able to communicate directly and *instantaneously* with key men anywhere on the job, saving man-hours and, perhaps, even human life.

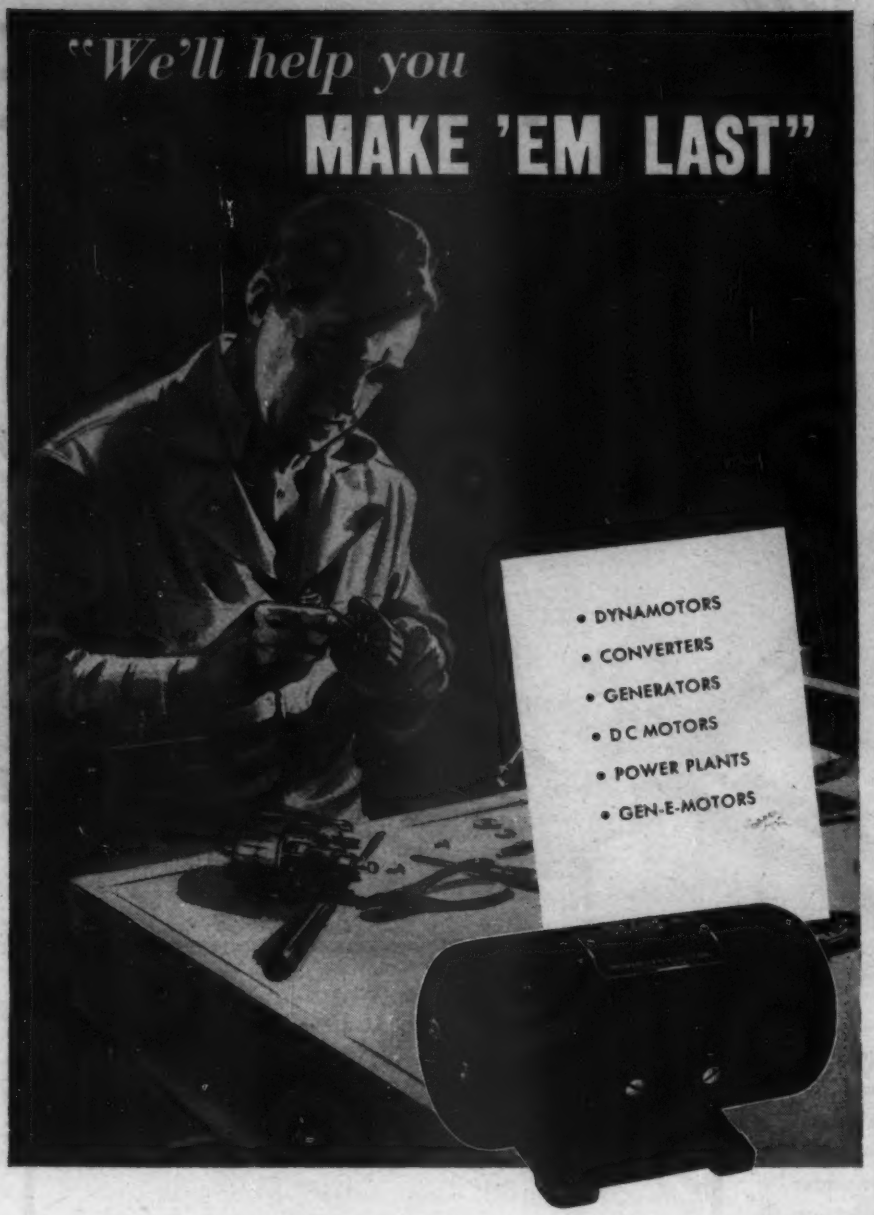
After the war, the various Communication Products listed below will again be entirely at the service of industry—for improving commercial broadcasting and helping to develop whatever new applications of radio and television peacetime may reveal.

Coaxial Transmission Line and Fittings • Sterling Switches • Auto-Dryaire • Antenna and Radiating Systems • Q-Max A-27 Radio Frequency Lacquer

Communication PRODUCTS COMPANY

744 BROAD ST. NEWARK, N. J.

FACTORY: 346 BERGEN AVE., JERSEY CITY, N. J.



Jim and His Fellow Workers are ON THE JOB!

They've pledged themselves to make your present Pincor equipment last for the duration. That's a big job but these men can do it. They *must* do it to insure that *all new* Pincor Products find their way to the fighting front. Pincor's number one job right now is to supply fighting men with tools of battle. Jim and men like him it possible for us to do this on an all-out war production basis. He'll take care of the home front while our plants supply the fighting front. Bring your problems to him—but please bring only PINCOR problems: there just aren't enough hours in the day to take care of any others.

PINCOR Products

PIONEER GEN-E-MOTOR

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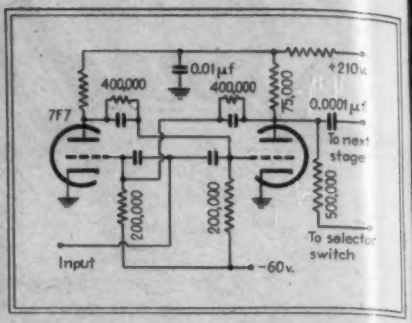


Fig. 3—Circuit of one of the scaling stages. Six of these are employed in cascade

receiver used is a superheterodyne. The circuit is conventional except that tuned lines are used for the r-f tuning elements. The frequency used is 180 Mc, and the lines are about 25 cm long. Two stages of r-f amplification are followed by the converter and these stages contain acorn type pentodes. The intermediate frequency is 11 Mc and the i-f amplifier has a band width of about 3 Mc. A single audio stage follows the 6SQ7 second detector.

Receiving Antenna

The output signal from the cosmic-ray radiosonde is a very short pulse, and is similar to the interference caused by automobile ignition so the receiving location must be carefully chosen. A directive antenna array improves signal strength and signal-to-noise ratio. The array consists of a three-element parasitic array, with one element spaced a quarter-wavelength behind the antenna, and one placed a half-wavelength on each side of the antenna. With this array the output voltage of the receiver is increased by a factor of four over a single half-wave antenna. During a flight, the transmitter may be located with a precision of about 10 deg.

Recorder

The output from the receiver is passed into a scaling circuit to obtain a slow counting rate to operate the recording pen. The essential parts of the circuit are shown in Figs. 2, 3, and 4. The first unit, Fig. 2, constitutes a multivibrator circuit acting as a pulse equalizer and pulse sharpener for the scaling circuit proper. The scaling circuit, Fig. 3, consists of double triode tubes in cascade, each tube being connected as shown. Six tubes are used to obtain a scale of 64.

A selector switch allows the output

GLASS CLOTH BASE FORMICA

New AND *Better!*

WHEN progress in research had produced a cloth made from glass fibres—which seems like a miraculous product—it presented Formica with a new base material that made possible a product with properties of great usefullness.

Grade FF-10 made with a fabric of glass cloth combines excellent dielectric strength and other insulating characteristics with exceptional heat resistance. It is an ideal material, for instance, for motor slot wedges where heat may sometimes reach 350° F.

Another grade made also with glass cloth is FF-41, has been developed especially to resist arcing or "tracking".

In the new post war products these new grades will be widely used, greatly increasing the durability and dependability of performance.

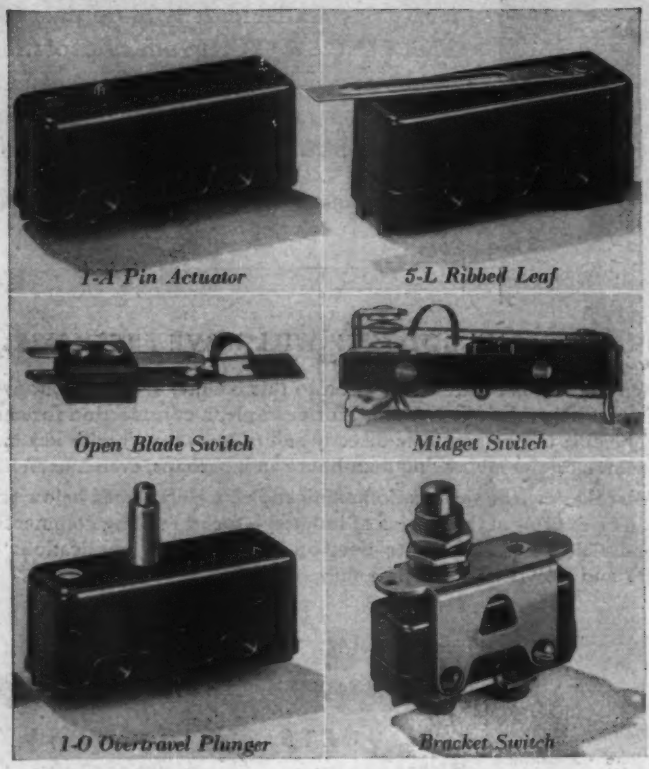
THE FORMICA INSULATION COMPANY, 4661 SPRING GROVE AVENUE, CINCINNATI 32, OHIO

● Better contact and higher operating speed is assured with the patented rolling spring ACRO SNAP SWITCH. When we say BETTER CONTACT we definitely mean BETTER CONTACT with the same operating pressure. This minimizes contact burning and greatly lengthens switch life. Many types of ACRO SNAP-ACTION SWITCHES are used in aircraft and other vital war equipment where unfailing performance is essential. If you have not yet handled and studied the ACRO rolling spring SNAP-ACTION SWITCH an experience is awaiting you.

IN WRITING, KINDLY EXPLAIN NATURE OF APPLICATION YOU CONTEMPLATE

ACRO ELECTRIC COMPANY

1316 Superior Ave., Cleveland 14, Ohio



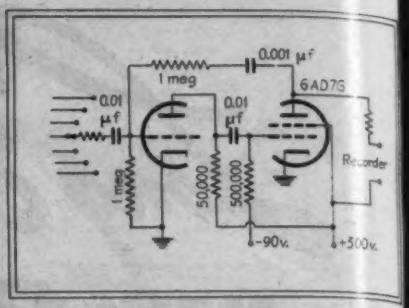


Fig. 4—Output of the scaling circuit feeds a 6AD7G which is connected as a multivibrator to operate the recording pen

to be taken from any desired stage and connected to the 6AD7G stage, Fig. 4, which forms the output multivibrator to operate the recording pen. A calibrating switch inserts the a-c frequency at the input and allows the scaling action to be checked at any time.

The cosmic-ray counts are registered as sharp pulses and the barometer signals give a steady deflection of the recording pen for about a second. Actually the barometer signals consist of a very rapid succession of pulses, but even at high scaling factors these are so rapid as to hold the pen deflected. When scaling factors of 16 or higher are used, the statistical fluctuations in the original counts are largely removed, and the record appears as a succession of approximately evenly spaced pulses.

• • •

A Dielectric Meter

By JOHN H. JUPE
Middlesex, England

A BRANCH OF ENGINEERING which has up to the present received little attention is the measurement of permittivity (dielectric constant) and it is one which will well repay the attention of the electronic specialist.

It has long been known that in absolute electrostatic or magnetic systems of measurement a hypothetical factor must be introduced in order to arrive at rational results. These two factors are permittivity and permeability, and they are joined by the expression involving the speed of light in the common theories of dimensions.

In general engineering usage, all substances have permeability or permittivity and it is a basic characteristic of matter that any changes in the substances themselves should be

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SPECIAL RF CHOKES

In addition to our standard line of "Designed for Application" RF chokes, we illustrate herewith just a few of the special types for special applications. Consult our district offices about your requirements: No. 1 is a tapped delay-line unit; No. 2, a small size universal type RF choke; No. 3, a compact single hole mounting multi-pie unit and No. 4 one of our No. 34200 series of high inductance single pie units on new improved type of pressed steatite form.

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accompanied by changes in one of the factors. Take water, for example; in the liquid state its dielectric constant is 81, when frozen it drops to 3.1 and in the form of vapor falls further still to 1.000705. Yet industrial technology has practically ignored this and allied phenomena.

To a slight extent, permeability changes are used to measure other changes in ferromagnetic materials. Permittivity changes, although presenting much wider scope, are only at the beginning of being used as a basis of analysis and control.

Previous Investigation

A great deal of the fundamental work in enlarging the field of permittivity as an important factor in science and industry has been done by Professor L. Ebert since 1924. He worked at Copenhagen in Denmark and later at Wurzburg and Karlsruhe in Germany. To the great advantage of science, one of his prominent collaborators, Dr. H. S. Simons, came to Great Britain in 1938 and has remained here, working on scientific research.

Starting from investigations on dielectric constants and dipole moments and from testing a wide variety of substances Dr. Simons has developed the dielectric meter into an instrument which avoids the disadvantages of a purely laboratory set-up. Commercial manufacture is quite possible and if war had not broken out would have been arranged. All the features required for scientific and industrial purposes are contained in the instrument, combined with reliability and simplicity where routine measurements are concerned.

Method of Operation

The fundamental principles are quite simple but the actual technique varies a great deal. It has, however, been standardized for a number of purposes. The basic electrical circuit is shown in Fig. 1.

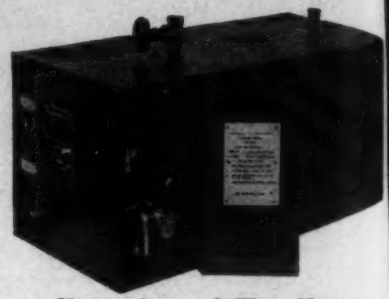
Quartz crystal control is used in the first oscillating circuit, which works at a frequency of 1 Mc. In the second oscillating circuit the frequency is varied according to the capacitance of the measuring container plugged in at *M*, couplings and inductances being of course suitably chosen. The total capacitance in the circuit of VT_2, with the test substance inserted, can be set with ex-

HUNTER HEATERS MADE FOR RAPID WATER HEATING

Automatic Gasoline Burning Models Designed for Mobile Service Units

CLEVELAND, OHIO—A gasoline burning water heater that will supply water at high temperature, and that is capable of automatically maintaining a continuous supply, has been perfected by Hunter and Company of this city, makers of Hunter Universal Gasoline space heaters.

Two models are at present available. One is a portable unit with a ten-gallon pressure tank that is suitable for connection to any permanent or emergency water supply. It is completely automatic. The other is a five-gallon unit with a gravity type tank, designed to heat small quantities of water in a hurry. This heater is meant to be permanently installed in any kind of mobile service unit where there is frequent need for hot water. It fastens to a wall, and may be filled through an opening in the top, or connected to a hand pump or to a pressure water system.



Hunter Automatic Water Heater

In both models, the heating element is a Hunter Universal Gasoline Burner, with "Sealed in Steel" flame, adapted as an immersion unit. The steel tube burner, with its terrific heating capacity, is immersed deep in the liquid to be heated. Unusual results are obtained in speed of heating and flexibility of automatic control. The same principle has been used by Hunter in special applications in storage or shipping tanks to protect oil or other fluids against cold.

These advantages, combined with the fact that the Hunter burner operates on any kind of gasoline, from truck fuel to highest octane, give Hunter Water Heaters an almost unlimited range of usefulness in mobile photographic, laboratory or hospital units, in field service units of all kinds . . . anywhere it is desirable to have an extremely simple and effective means to supply hot water.

More complete details about Hunter Water Heaters and their application may be obtained from Hunter and Company, 1558 E. 17th St., Cleveland, Ohio.

(Advertisement)

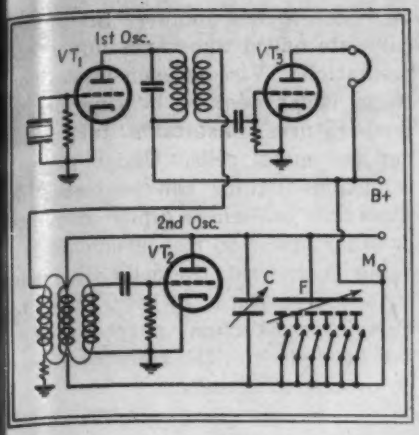


Fig. 1—Circuit of instrument for measurement of dielectric constant by compensating for changes in frequency of an oscillator caused by a substance under test at *M*

treme accuracy by means of the variable capacitors *C* and *F*, which are in parallel with *M* in such a manner that the oscillations of VT_3 heterodyne with those of VT_1 either directly or on some harmonic. The heterodyne beats are detected by the rectifier and earphone circuit of VT_3, or alternatively by a loudspeaker, reflecting galvanometer, or cathode-ray tube.

It will be noticed that the measurements are carried out by compensating, with the variable capacitors, the change in capacitance due to inserting a specimen into the circuit of VT_1. Either measuring capacitor can be used alone or they can be combined. The coarse one *C* covers a range of about 100 $\mu\mu$f, while the fine one is subdivided into six steps of about 1 to 50 $\mu\mu$f. These steps can also be used singly or in combination.

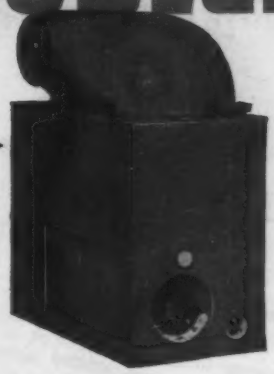
The lowest sensitivity when using the coarse capacitor enables one to read 0.1 $\mu\mu$f and to estimate 0.05 $\mu\mu$f. When the 1-$\mu\mu$f steps of the fine capacitor are used one can read 0.001 $\mu\mu$f and estimate 0.0005 $\mu\mu$f. By this arrangement of capacitors it is possible to apply to any problem in hand the optimum accuracy and sensitivity required by the circumstances.

The exact details of the construction of the measuring containers is very important, and it is not exaggerating to say that the success of the whole method depends on them. In the first case, it is necessary to cover the whole range of dielectric constants, from those of gases, which are practically unity, to those beyond that of water (81). The electrical design of the oscillator circuits has

MODEL UHX—10,000 BTU

HUNTER HEATERS MIGHT SOLVE YOUR PROBLEM

MODEL UH2—25,000 BTU



MODEL UH3—40,000 BTU

Burn any type of gasoline—from truck fuel to 100 octane!

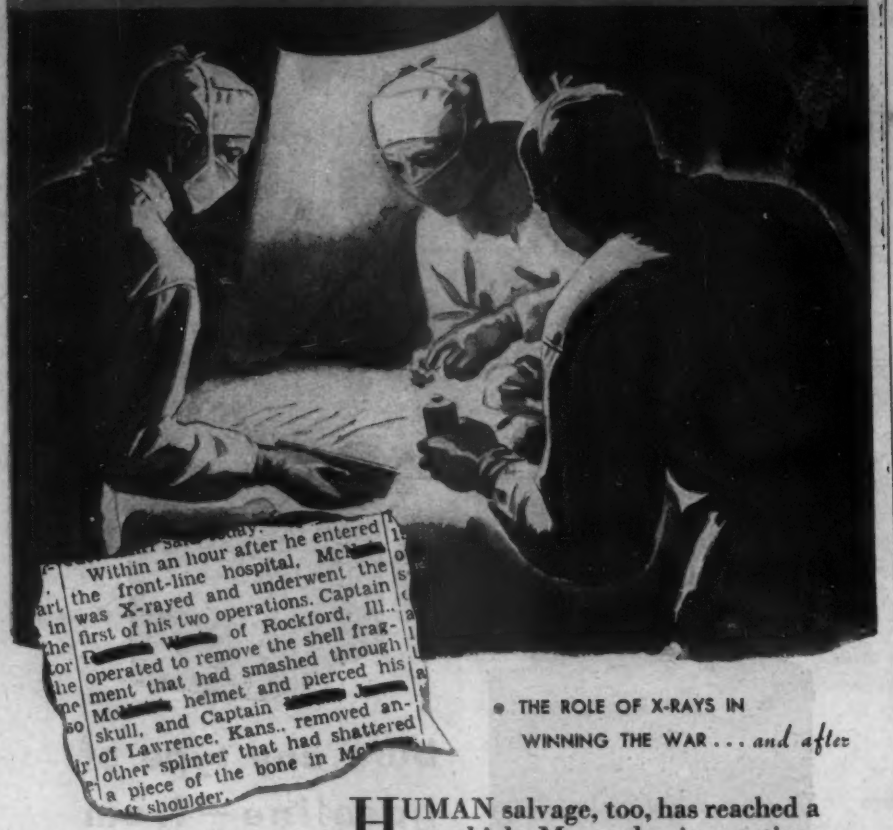
Uses for Hunter Universal Gasoline Heaters are too widespread and varied to list completely, and are multiplied daily by the imagination and ingenuity of men who build, buy or command equipment for the service or supply of our armed forces, or essential civilian activities.

We build a variety of small, powerful units, each with a range of applications to which it is especially suited. YOUR heating problem may be one of these, or it may be one on which Hunter heating engineers can assist you in applying the extremely flexible basic units of Hunter Heaters to do exactly the job you need done. In either event, we shall be glad to furnish further information specific to your particular interests.

BULLETIN HB-3 ON REQUEST

HUNTER AND COMPANY
Aircraft Equipment
1558 E. 17th St.
CLEVELAND • OHIO

Every chance for a safe recovery... *Thanks to the* X-RAY!

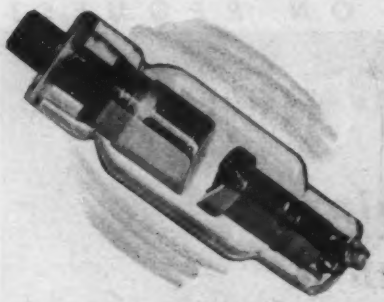

Within an hour after he entered the front-line hospital, Mc[redacted] was X-rayed and underwent the first of his two operations. Captain [redacted] of Rockford, Ill., operated to remove the shell fragment that had smashed through Mc[redacted] helmet and pierced his skull, and Captain [redacted] of Lawrence, Kans., removed another splinter that had shattered a piece of the bone in Mc[redacted] shoulder.

• THE ROLE OF X-RAYS IN WINNING THE WAR . . . *and after*

HUMAN salvage, too, has reached a new high. Many clearing stations are now equipped with mobile X-ray Units. The wounded are given X-ray examination immediately upon reaching the station—extent of injury determined, foreign bodies located, insuring proper treatment with the minimum of delay and without guesswork.

This speedy wound analysis and treatment has saved hundreds of young American lives and put them on the road to a safe recovery.

The war-time developments and extension in the use of X-rays will not be forgotten when the war is over. The improvements in apparatus and techniques, the discovery of many new uses for this miracle of modern science, will result in the employment of its magic not only in treatment and diagnosis of the sick and injured, but also for a vast variety of industrial applications as well. The further unlocking of Nature's secrets in many fields awaits the application of this scientific tool.



THE X-RAY TUBE IS THE HEART OF THE X-RAY MACHINE...
The majority of leading makes of X-Ray apparatus are equipped with Machlett Tubes.

MACHLETT *Laboratories Inc.*
SPRINGDALE CONNECTICUT

LARGEST PRODUCERS OF X-RAY TUBES
X-RAY TUBE SPECIALISTS SINCE 1898

to be considered, likewise the physical state of the substance under examination. Viscose substances or those which require heating up to temperatures unsuitable for glass demand metal cells. Under normal conditions liquids can be tested in glass cells but where dipole moments or other precision measurements are being dealt with, the cells are made with thermostatic jackets. For industrial production purposes they can be built into the sides of rooms or process chambers.

Applications

From an industrial point of view, the successful applications of the instrument have been largely dependent on the design of special cells, the number of types already being quite large. Foils and plates require one type while grains, powders and manufactured goods such as cigarettes demand something totally different. Each type is made in the common ranges of the substances concerned. Liquid testing cells, for example, are made for ranges of dielectric constants of 2 to 4, 2 to 10.8, 8 to 37 and 30 to 120.

It is useful that the dielectric constant of water is high compared with most other substances since humidity tests are used in many industries and the use of dielectric analysis in moisture determination has a particularly interesting aspect. The dielectric meter can determine even minute traces of humidity and, in the case of water in oil (dielectric constant 3 to 4), an accuracy of about 0.01 percent is quite usual, a very important point where switchgear and transformer oils are concerned.

The chemist who understands the difficulties of moisture determination under special circumstances will ap-

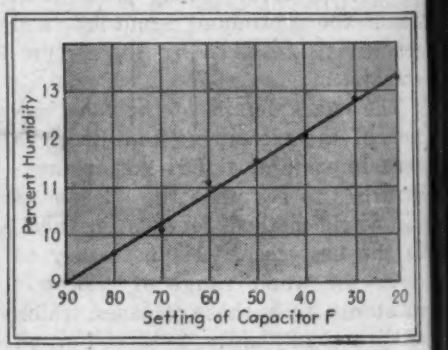


Fig. 2—Calibration curve of moisture determination of cigarettes in drying oven

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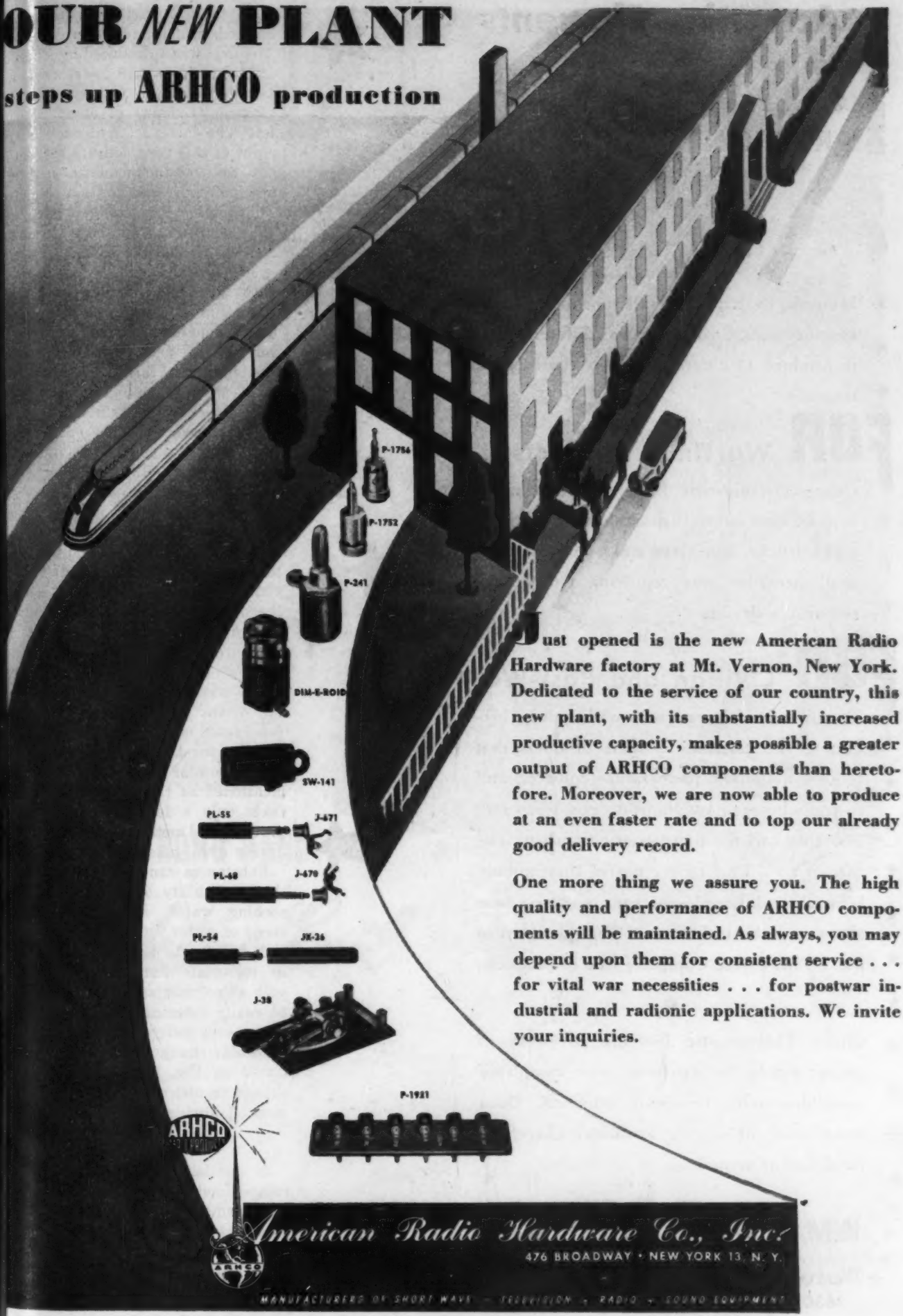

Just opened is the new American Radio Hardware factory at Mt. Vernon, New York. Dedicated to the service of our country, this new plant, with its substantially increased productive capacity, makes possible a greater output of ARHCO components than heretofore. Moreover, we are now able to produce at an even faster rate and to top our already good delivery record.

One more thing we assure you. The high quality and performance of ARHCO components will be maintained. As always, you may depend upon them for consistent service . . . for vital war necessities . . . for postwar industrial and radionic applications. We invite your inquiries.

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Engineered from thermostatic bimetals, in shapes and of a type to meet your specific needs. Chace utilizes 25 different alloys to produce 35 different types of thermostatic bimetals.

FOR Wartime Products

Chace Thermostatic Bimetals are regularly used in vital control instruments for aircraft, tanks, trucks, cars, jeeps and numerous other implements of war requiring temperature responsive device.

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To you manufacturers who will soon be producing the essential civilian products that require automatic temperature controls, and to you who are now planning post-war products that call for thermostatic actuating elements. . . . Two new types of thermostatic bimetals and three important manganese base alloys have been developed by and added to the W. M. Chace Company line of products.

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Chace Thermostatic Bimetals are sold in shapes ready for assembly, also completed assemblies with terminals attached. Data sheets and engineering assistance cheerfully furnished on request.

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Manufacturers of
Thermostatic Bimetals and Special Alloys
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preciate two further examples of methods which have been developed. The first was introduced by Ebert in 1934 and in it, the moisture is extracted from the test specimen by dioxane (Exluan) of standard purity. The increase in dielectric constant of this very delicate reagent is a measure of the amount of moisture originally present in the specimen. This method has many applications and is often the most accurate method of analysis.

The second method can be used with granular or powdered substances in which the interstices may be an appreciable part of the total volume and are a variable factor. The answer to the problem is found in a variation of the immersion method used in certain other physical measurements. The specimen is immersed in a liquid, the dielectric constant of which is known. Under such conditions the changes of the combined system, powder plus liquid, compared with the liquid alone, permit a quick and easy graphical determination of the dielectric constant, depending, as in the case of the first method, on the amount of moisture present. An example of moisture determination in cigarettes is shown in Fig. 2. Other substances whose moisture can be determined by the means just described are pulp for sugar manufacture, rape seed, oil cake, wood, coal, paper, cocoa, and tannin powder. The last substance is mentioned as the suggested method takes only a few minutes whereas the standard method, using a vacuum drying oven, takes 8 to 10 hours.

Substances can also be tested for their capability of repelling or absorbing water, and the diffusion speed of water into insulating materials can also be determined. Changes in materials during manufacture, such as polymerization or aging, can be easily detected owing to the extreme sensitivity of the method to molecular change. This is well illustrated by Fig. 3, which shows the change in dielectric constant of linseed oil during boiling.

Gas Analysis

A special case where dielectric measurements are particularly difficult and require high grade apparatus is in gas analysis, as in most cases the constant is near unity in value, the difference between gases being only in the fourth or lower

LIKE A STRONG HAND...

Crushing Evil

The first duty of government is the protection of its people. Protection from dangers at home, as well as from enemies abroad. Protection from fire and flood—from prowling thieves, kidnappers, killers—from danger of injury by reckless motorists.

In modern communities emergency communications systems developed by RCA play a vital part in organizing the forces of society to combat these evils. RCA Police Radio Systems, and RCA radio systems for fire departments, forest rangers, highway patrols, public utilities, and flood control organizations, provide instant two-way communication between fixed or mobile points, for transmission of emergency information and instructions essential to maintenance of public order and safety.

RCA will gladly answer any questions about any type or application of RCA Emergency Communications Equipment. While present availability of this equipment is limited by war priorities, plans can be based on information you give us now that will speed an effective installation to meet your needs when the war permits.

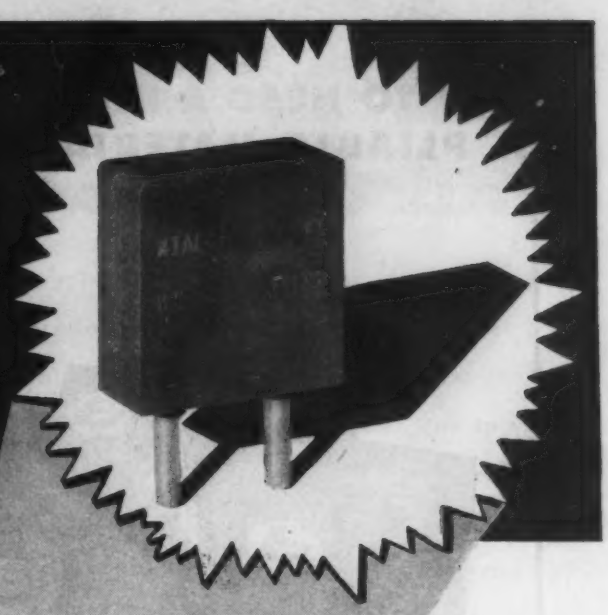
★ *BUY MORE WAR BONDS* ★

RCA

RCA EMERGENCY COMMUNICATIONS

RCA Victor Division • RADIO CORPORATION OF AMERICA • Camden, N. J.

The Impossible we do Immediately...



The miraculous takes a little longer. In the Air—on the Sea—in the Field... our Armed Forces are accomplishing the impossible daily—a routine, common occurrence! With Henry, such feats are not performed every day, but we, too, have proven *our ability* to accomplish the impossible.

A major wartime crystal problem arose in the "plastic holder" which contains the oscillating blank. Soldered or bolted connections were insecure; solder flux melted at high temperature, impaired crystal operation; drill particles vibrated loose into the holder cavity; pin entries permitted leakage.

Our engineers saw these defects, refused to believe that new plastic molding techniques were impossible.

The result:

Henry developed a revolutionary new type holder. Pins, contact plates are now welded permanently together—molded as an integral part of the complete holder. This new holder is now available to the industry in a number of different types.

Thus, cleaner, sturdier, tighter crystal holders than any previously made are now being manufactured and satisfactorily used by our Armed Forces. Another apparently *impossible* task has been accomplished. Through war...into peace...look to Henry for the manufacture of Radio Equipment which will help you accomplish the seemingly impossible.

HENRY *Manufacturing Company*

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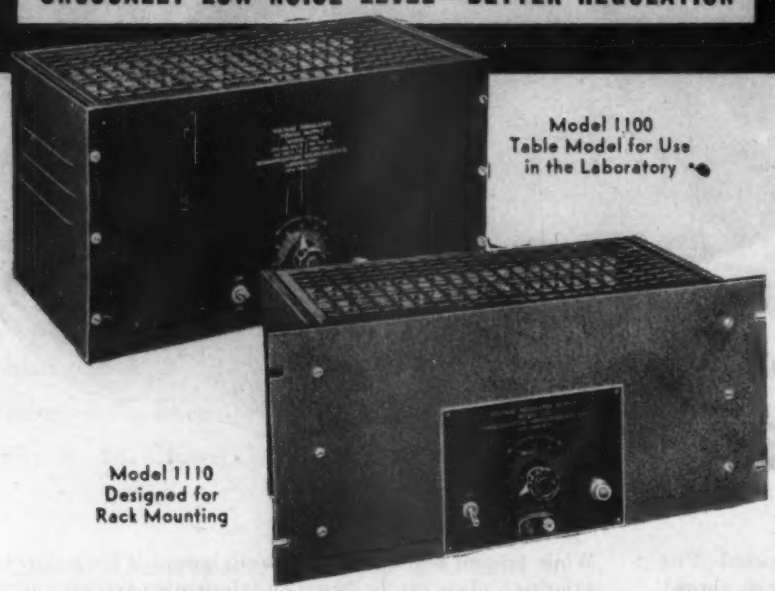
2 Important New CML Developments

CML 1100 | CML 1110

VOLTAGE REGULATED POWER SUPPLY

UNUSUALLY LOW NOISE LEVEL—BETTER REGULATION



Model 1100
Table Model for Use in the Laboratory

Model 1110
Designed for Rack Mounting

Identical in performance, these units employ a special series regulator circuit. To insure low noise level and better regulation, a high gain two stage control circuit is used instead of the conventional single stage circuit.

Power Source: 105-115-125 volts—50-60 cycles
Regulated DC Output: 225-300 volts at 200 milliamperes
300-325 volts at 180 milliamperes
Noise Output: Less than 5 millivolts.
Voltage Change: No load to full load less than 1 volt
Output Voltage: Constant with 10% line voltage change
Unregulated Heater Supply: 6.32-5 amperes

WRITE FOR DESCRIPTIVE BULLETIN

COMMUNICATION MEASUREMENTS LABORATORY
120 GREENWICH STREET • NEW YORK, N. Y.

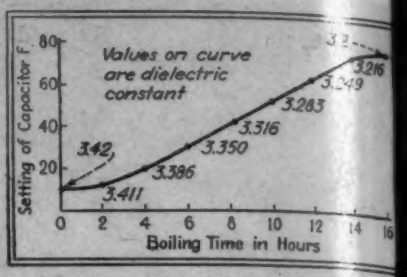


Fig. 3—Curve of variation in dielectric constant due to molecular change of linseed oil during boiling period of several hours

decimal point. In this field the dielectric meter excels, determinations within 10^{-7} of a dielectric constant unit being attainable.

It should be remembered, however, that a single measurement will not define a multitude of unknown factors connected with a substance and permittivity methods are subject to the usual routines of analysis. Systematic examinations which in complicated cases have proved most useful are combinations of one or more of the qualities such as temperature, viscosity, conductivity, etc. In a similar way, Ebert's method of dipole moment determination is based on measurements of dielectric constant and refractive index.

To choose only one of the potentially valuable industrial results of these dielectric measurements is to quote the possibility of predicting from determination of dielectric constant, dipole moment and surface tension as to whether a solvent will dissolve a particular substance of high molecular weight and even as to what degree of viscosity the resultant solution may have.

In the case of production tests, or

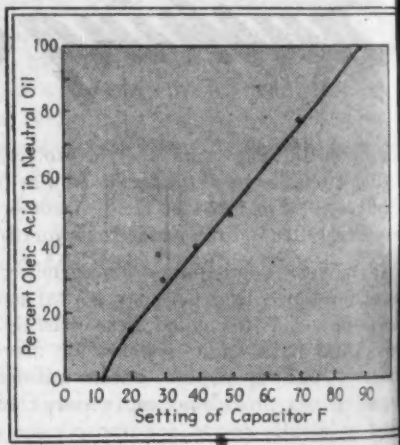
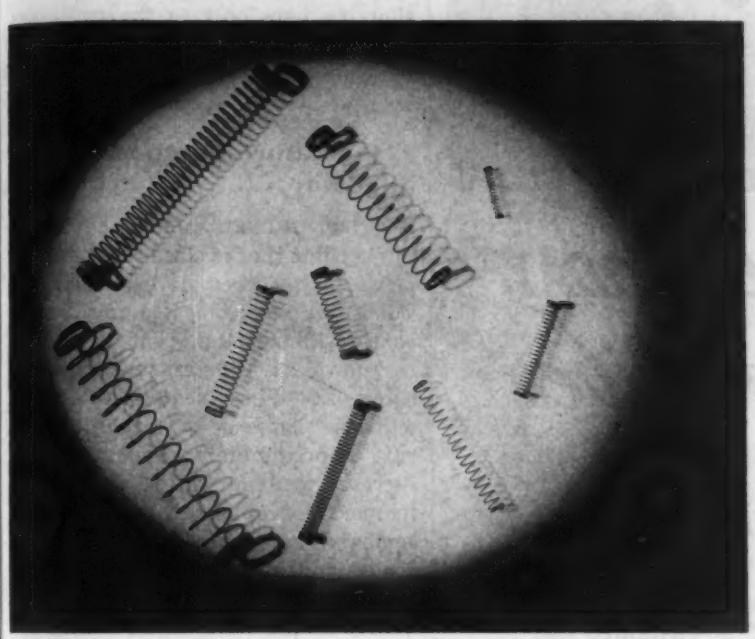


Fig. 4—Calibration of the dielectric meter can be accomplished with standard samples as in this curve of various amounts of oleic acid in neutral oil

To the Seven Men in Eight who Never Need Anything but "Average" SPRINGS

As producers of over a million and a half beryllium copper coil and flat springs a week, we at Instrument Specialties are in an ideal spot to see how many "average" spring orders are filled before one "fancy" spring job comes through. We are also in the ideal spot to see how readily many springs which function under "average" conditions may be improved in their operating characteristics by "Micro-Processing" — an exclusive I-S process.



There is no premium on micro-processed beryllium copper brush springs which increase brush life 25% or more, because that is the only way we know how to make them. And, in the bargain, our production methods and material in stock assure quick delivery.

There is no "mumbo-jumbo" about micro-processing. We obtain closer tolerances, higher tensile strength, consistent uniformity, higher electrical properties, and minimum drift, with step-by-step precision control which begins with the wire or strip itself. So, we produce average springs by the same method that we use for fancy springs — and you benefit because micro-processing makes the most of the inherent qualities of beryllium copper, regardless of your service requirements.

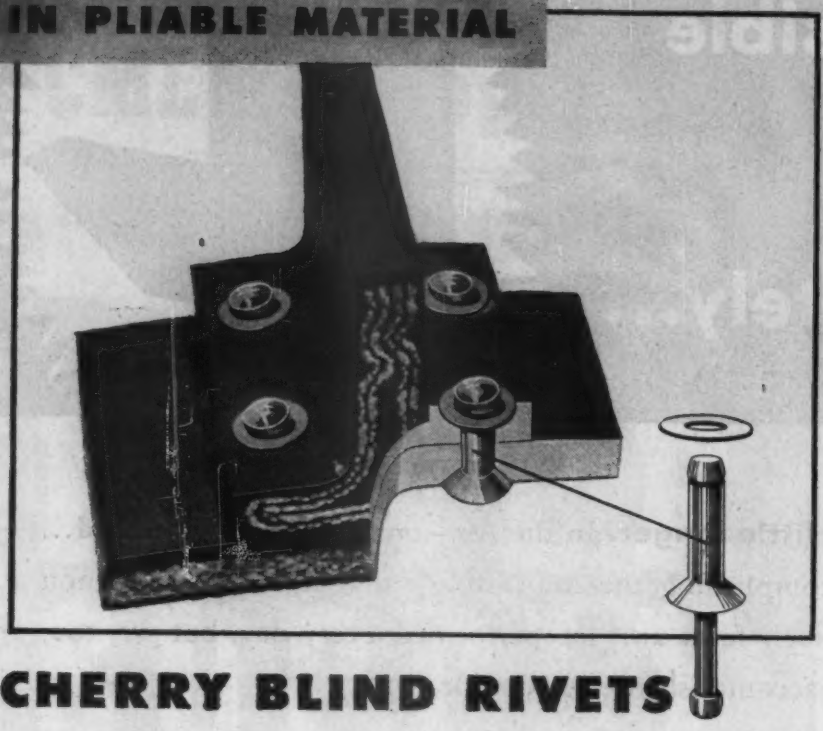
The best way to prove the value of micro-processing is for us to show you performance on your own springs. Our sample department is set up for quick action. Send us springs, drawings or working specifications. Micro-processing does make a significant difference — even on average springs.

A limited quantity of the "Bibliography of Beryllium Copper" is available. A note on your company letterhead will bring your copy by return mail.

INSTRUMENT SPECIALTIES CO., INC.

DEPT. D, LITTLE FALLS, NEW JERSEY

HOW TO HEAD A RIVET IN PLIABLE MATERIAL



CHERRY BLIND RIVETS

CHERRY BLIND RIVETS of the hollow type are shown above holding a rubber cleat to a rubber conveyor belt. Both hollow and self-plugging types of Cherry Rivets make ideal fasteners for pliable material because they are headed by means of a pulling force. There is no hammering on rivet heads—no bucking bar needed.

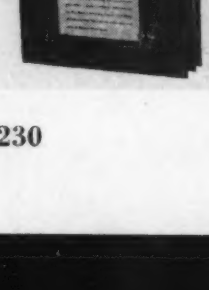
Application is faster than with conventional rivets and may be done with inexperienced labor.

There are undoubtedly many places where you too can use Cherry Rivets to save time, reduce costs and get a better job. Ideal for speeding up work on war jobs. Get the complete story on Cherry Rivets now.

WRITE FOR HANDBOOK telling how to use Cherry Rivets. Address Department A-120, Cherry Rivet Company, 231 Winston St., Los Angeles 13, California.

Self-plugging type with brazier and countersunk heads. Mandrel is pulled through rivet and permanently plugs it.

CHERRY RIVETS, THEIR MANUFACTURE AND APPLICATION ARE COVERED BY U. S. PATENTS ISSUED AND PENDING.



Cherry Rivet Company
LOS ANGELES, CALIFORNIA

where mixtures are concerned, the calibration of the instrument and its associated measuring cells is generally carried out with chemicals of standard purity or against satisfactory samples, the results being as shown in Fig. 4.

The trouble of carrying out a series of tests with a view to obtaining well defined standards is easily compensated by the great gain in working speed, accuracy, sensitivity and quickness of repetition. Less skilled labor can be used in carrying out the tests, leaving engineers free for more important work.

• • •

Electronics—Present and Future

THE APPLICATIONS of electronic equipment to industrial, communication and television uses, and the marketing problems they will create in the future, are reviewed by J. S. Smith, in charge of industrial advertising and sales promotion for the Apparatus Department of General Electric Co., in *Industrial Marketing* for August and September, 1943.

He points out that industrial electronic devices are definitely "overdesigned" for safety and reliability, while electronic consumer goods in the low-price field usually have a lower margin of safety. In marketing parts in either field the needs of the market and replacement outlets should be well considered.

Electronics is a big science—so big that we do not really know where it will take us. This much, though, is certain. No one organization, perhaps no ten organizations, can cover all its ramifications even today in its infancy. And the industry is big enough for all. The electronic industries together have a tremendous opportunity to do America real service in planning for postwar progress and in absorbing the thousands of electronics-trained men of the second AEF.

—◆—

REFUSING to believe that metal poles were essential for telephone lines in Australia, American Signal Corps engineers put in one wood span near a regular line of metal poles. In about four months, according to Major Jack Lea, only the glass insulators, wire, bolts and braces were left; white ants got the rest.

More NEEDED TODAY
... than in September

WITH Allied armies on the march and the retreating Axis forces destroying all existing facilities, the need for telephone communications systems is soaring.

The record of the telephone equipment manufacturing industry in this war should be a sufficient guarantee that our fighting men will continue to get what they need, regardless of the enormity of the job.

The men and women at "Connecticut" have made a record that stands out even in an industry famous for its wartime accomplishments.

We submit the record we are compiling now, as evidence of ability to serve postwar America. We are glad to consult with manufacturers seeking help on electronic or electrical product developments — also with engineers who have developed ideas that might round out our postwar plans.

CONNECTICUT TELEPHONE & ELECTRIC DIVISION

GAI GREAT AMERICAN INDUSTRIES INC.

MERIDEN, CONNECTICUT

ARMY NAVY E

Engineering, Development, Precision Electrical Manufacturing

© 1943 Great American Industries, Inc., Meriden, Conn.

Reference Sheet Data

IN CONNECTION with the ELECTRONICS REFERENCE SHEET entitled "Characteristics of Resonant Transmission Lines", by J. B. Epperson on page 139 of the Oct. 1943 issue of ELECTRONICS, the author points out that the quarter wave section (second from bottom on page 140) should be identical to the first quarter-wave section of the curves for the 450-deg. shorted line above it. Likewise, the half-wave section at the bottom of the page should be dentical to the first half-wave section of the curves for the 360-deg. open line above. Vertical dimensional lines crossing the transmission lines drawn under the curves represent shorting bars only in the two cases where notes definitely indicate that the lines are shorted.

• • •

Temperature Compensator 30 Alloy

AN IRON-NICKEL ALLOY having a Curie point that is close to room temperature has been developed by the Carpenter Steel Co., Reading, Pa. It contains about 30 percent nickel, and is known as Temperature Compensator 30. When heated, this alloy will lose magnetic permeability at a rate approximately proportional to increase in temperature, until at a temperature of about 130° F it becomes virtually nonmagnetic. When cooled to the original temperature the alloy regains magnetic permeability at the same rate. This property suggests applications of the alloy to compensate for the effect of temperature change on electrical apparatus.

The alloy is formed into several types by changing the composition and heat treatment. A temperature-permeability curve is shown for one typical type. Permeability values were determined at a magnetizing force of 46 oersteds, a value generally used in testing and over saturation.

One application of the alloy for temperature compensation is in providing a magnetic shunt across the poles of a permanent magnet, or between like poles of permanent magnets, as in a watthour meter. In an uncorrected meter the strength of the magnetic field varies with temperature, decreasing as temperature rises and increasing when temperature drops. A shunt made of compen-

Do You MAKE ASSEMBLIES LIKE THESE THE HARD WAY?

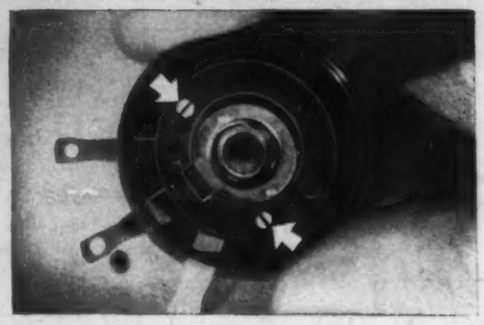
Change over to the simpler P-K Self-tapping Screw method, and you will set new records for Speed!

Your efforts to step up production are sure to show quicker and better results if you will first clear the way by simplifying your assemblies with Parker-Kalon Self-tapping Screws . . . the quickest means of making many fastenings.

Question every fastening job on your drafting boards, and on your production lines, *now*. Like the makers of the three products illustrated, you'll probably find numerous places to save work-hours and get better assemblies with P-K Self-tapping Screws.

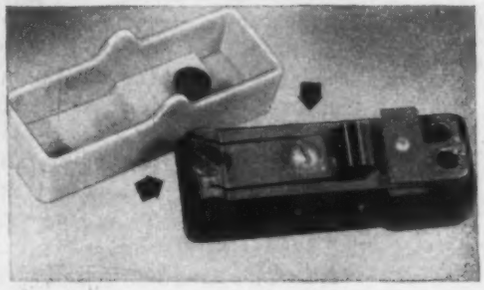
Ask for a P-K Assembly Engineer to help you check your fastening jobs. Or, mail assembly details for recommendations. Parker-Kalon Corp., 190-200 D, Varick St., New York 14, N. Y.

SEE HOW IT PAYS TO CHOOSE
the simplest fastening method
A Machine Screws in THREADED INSERTS
B Machine Screws in TAPPED HOLES
C PARKER-KALON SELF-TAPPING SCREWS
THREADED INSERTS ARE COSTLY
TAPPING IS SLOW AND COSTLY
ELIMINATE TAPPING AND INSERTS!
LOOSENING INSERTS SLOWS UP ASSEMBLY – MAY WARRANT PART
TAPPED THREADS IN PLASTICS ARE WEAK
FORM THEIR OWN STRONG THREADS!
INSERTS HAVE UNCERTAIN HOLDING POWER
TAP BREAKAGE TROUBLESOME – BLIND HOLES MADE TO TAP
NO DIFFICULT TAPPING – NO STRIPPED THREADS!
INSERTS SLOWEST, COSTLIEST WAY SECURITY IS POOR
TAPPING ALMOST AS SLOW AND COSTLY AS INSERTS SECURITY IS POOR
PARKER-KALON SCREWS FASTER, CHEAPER, MORE SECURE THAN TAPPING OR INSERTS
Question every fastening! . . . you save man-hours, lower costs, get better assemblies by using P-K Self-tapping Screws.
TYPE "Z" THREAD-FORMING SCREWS
TYPE "F" THREAD-CUTTING SCREWS
TYPE "U" FOR PERMANENT FASTENINGS
PARKER-KALON
Quality Controlled
SELF-TAPPING SCREWS
Give the Green Light • To War Assembly



SOLVED DESIGN AND PRODUCTION PROBLEM
RIVETS WERE IMPRACTICAL . . . TAPPING COSTLY

In developing this volume control the engineers met with difficulties in fastening a Bakelite ring into a thin Bakelite Molded housing. Rivets proved impractical because they cracked the ring. Machine screws were unsatisfactory because it was difficult and costly to tap such small holes. P-K Type "Z" Screws, turned into plain molded holes, gave a perfect result with unmatched simplicity.



SAVE 2 TO 3 MINUTES TAPPING-TIME PER PART

"Without P-K Self-tapping Screws, the design of this Acro-snap Midget Switch would be impracticable," says the Acro Electric Co. of Cleveland. Use of P-K Type "F" Screws to fasten the metal contact to the plastic base also saves the two to three minutes that tapping would require. The Type "F" Screw *cuts* a machine screw thread as it is turned in. The fastenings have the security that is needed for this switch, which is used in large numbers on tanks, aircraft, and other important war equipment.

DESIGN AND PRODUCTION COMPLICATIONS
AVOIDED IN THIS PLASTIC PRODUCT

Standard Register Company used Type "Z" Screws as trunions for a door, eliminating a hinge. Type "F" Screws hold metal unit in plastic case; also fasten spring steel catch. Type "U" Screws fasten a hinge to the case. Tapping, metal inserts, lock washers are avoided. Fastenings are more secure than if made by other methods.

PARKER-KALON
Quality-Controlled
SELF-TAPPING SCREWS

STRUTHERS-DUNN
INCORPORATED

5,288 TYPES OF RELAYS

1321 ARCH STREET, PHILADELPHIA 7, PA.

DISTRICT ENGINEERING OFFICES ATLANTA . BALTIMORE . BOSTON . BUFFALO . CHICAGO . CINCINNATI . CLEVELAND
DALLAS . DENVER . DETROIT . HARTFORD . INDIANAPOLIS . LOS ANGELES . MINNEAPOLIS . MONTREAL
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Manufactured by

Consolidated Radio

Mass production of an extensive line of *small* and medium audio transformers enables Consolidated Radio Products to supply all your requirements. Twelve years' experience assures workmanship of high order combined with skill, precision and efficiency. The "last word" in manufacturing equipment makes Consolidated's small and medium transformers outstanding in every application.

Consolidated engineers will design transformers for special applications or will build to *your* specifications.

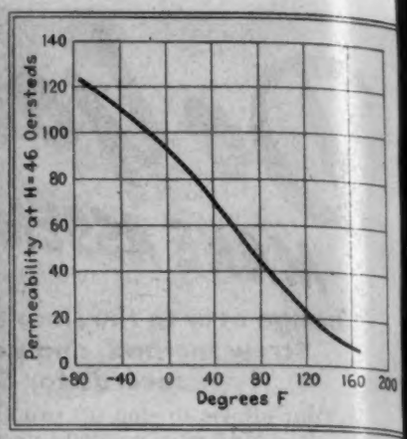
One of the coil-winding machines that make for the efficient mass production of Consolidated Radio transformers.

Electronic and Magnetic Devices

CONSOLIDATED RADIO

Products Company

350 W. ERIE ST., CHICAGO 10, ILL.



Variation of magnetic permeability plotted against temperature change for the new alloy, Temperature Compensator 30

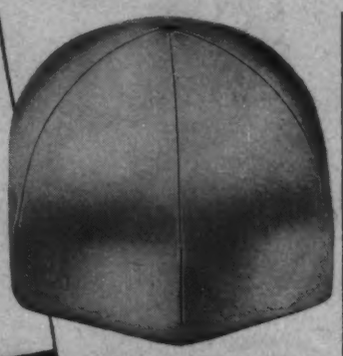
sator alloy, placed across like poles of the meter magnets, will bypass a relatively large amount of flux from the gap at low temperatures when the magnets are strong and the permeability of the shunt high. As temperature rises and the magnetic field weakens the permeability of the shunt decreases and it bypasses less flux. By selecting the proper alloy for the shunt the flux can be maintained constant and the error compensated.

A second application of the alloy is that of compensating for changes in inductive reactance resulting from temperature changes. In this case the alloy is sometimes applied by encircling one point of a closed copper circuit with a disc or plate of the material. The assembly is placed in the alternating field which is to be compensated. This type of compensation is also applied to watthour meters in addition to the magnetic shunt described.

A third application of the alloy is that of magnetically shunting part of the field of an electromagnet to compensate for changes in flux density resulting from variations in ambient temperature. In this case the change in flux density results from variation of resistance in the magnet winding with changing temperature and is the principle used in compensation of voltage regulators.

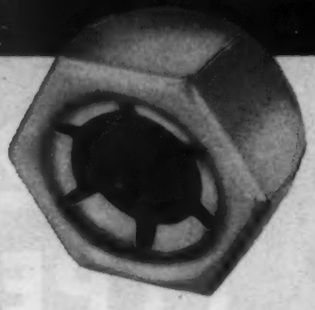
The alloy is usually supplied in the form of cold rolled bright annealed strip in either coils or straight lengths. Rockwell hardness ranges from aproximately B-70 to B-90, depending on the type. Temperature Compensator 30 can also be supplied in hot rolled and cold drawn bars where heavy sections are required.

Self-Locking
ACORN PALNUTS
The One-Piece Fastenings with the Three-Way Features

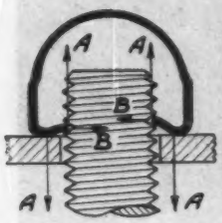


1. Hold Parts Tight
2. Hide Bolt Ends
3. Save Time, Labor, Weight, Cost

Illustration shows the pleasing effect obtained by Meissner Manufacturing Co., by using Self-Locking Acorn Palnuts to securely mount the I. F. Coil assembly to the Shield can.



• Combining unfailing security and pleasing appearance, Self-Locking Acorn Palnuts are the ideal fastenings for modern, streamlined electronics and radio equipment. Because of its powerful double locking action, one Acorn Palnut replaces an ordinary nut and lockwasher, saving one part and one operation. Rough, unsightly bolt ends are encased in a smooth round dome.



Double Locking Action

When the Palnut is tightened, its arched, slotted jaws grip the bolt threads like a chuck (B - B), while spring tension is exerted upward on the bolt threads and downward on the part (A-A), securely locking both.

Made of tempered spring steel, Acorn Palnuts are light in weight—low in cost—easily, speedily applied—can not loosen under vibration. Investigate Acorn Palnuts for present or postwar products. Send details of your assembly for samples and suggestions. Write for Palnut Manual No. 2, giving data on all types of Self-Locking Palnuts.

THE PALNUT COMPANY 77 Cordier St., Irvington, N. J.

Self-Locking PALNUTS

Metal Locators

(*Continued from page* 115)

In the case of short-circuits the signal should normally be fed into the short-circuited conductors. To locate a ground, apply a signal between the earth and the grounded conductor. When the grounded spot is passed over by the pickup coil the signal will decrease in amplitude.

Very frequently a power cable fault offers a high resistance to a low-voltage signal. In such cases the fault must be burned until the insulation carbonizes to a lower resistance. Another system is to apply a sufficiently high voltage to arc through the fault, but limit the current by means of a suitable reactor. The current flowing under this condition can be used as the tone signal for locating by means of the pickup coil.

Beat-Frequency Locator

In the public utility field the beat-frequency locator is very useful for finding buried manholes and other types of metal boxes used to protect gas and water valves and cable junction boxes. It is most effective in locating buried metal having a large surface facing toward the exploring coil, and hence is not ordinarily used for tracing small pipes. Large pipe lines can be traced as long as the depth does not exceed the penetration of the locator, determined by the frequency, the power fed into the pickup coil, and the diameter of the pickup coil.

Many different frequencies have been tried with this type of locator, and there seems to be no critical value. Frequencies as high as several megacycles have been used, but frequencies between 150 and 400 kc appear to be completely satisfactory. At low frequencies, more power can be used without exceeding the signal strength of 15 microvolts per meter at a distance of $\lambda/2\pi$ (or $157{,}000/f_{kc}$ ft.) as set by the Federal Communications Commission in sections from 2.101 through 2.104 of the FCC ruling applying to low-powered radio devices operating without licenses.

The circuit of an experimental beat-frequency locator designed by the author is given in Fig. 5. This circuit uses no detector or mixer, as

BZZZ . . . BZZZ . . . ugly rumors work their way from mouth-to-mouth. YOU HEAR that our best grades of food are sent overseas and we are given the leavings. YOU HEAR that the need for purchasing war bonds is just so much talk. YOU HEAR that inferior implements are given our soldiers.

THE truth of the matter is that these rumors are bare-faced lies . . . spread around to cause fear and confusion. America is still the best-fed nation in the world . . . it's more important than ever that you keep buying war bonds . . . and, as for inferior war materials, you know, and we know, that American equipment is the best. Speaking solely for ourselves, Kenyon Transformers have been put to any number of gruelling tests . . . and they've emerged with flying colors.

Yes, you hear all sorts of rumors these days. They're inspired to set Americans against each other . . . management against labor, color against color, race against race. Do your part to stamp out this evil practice. **Investigate before you believe!** Remember, united we stand, divided we fall.

BUY WAR BONDS—10% is only a start. Every dollar invested in war bonds is a vote for victory. KEEP ON BACKING THE ATTACK.

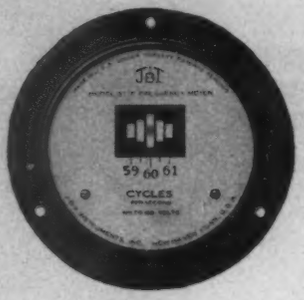
THE MARK OF EXCELLENCE

KENYON TRANSFORMER CO., Inc. 840 BARRY STREET NEW YORK, U. S. A.

They're Versatile!

Here are a few of the many models in the J-B-T line of Vibrating Reed Frequency Meters for measuring frequency of AC or interrupted DC. Vibrating reed indicates actual frequency or r.p.m.

● versatile because they are being used on portable engine-generator sets in the field, where mud and grit and vibration are the rule, not the exception — in laboratories, where accuracy is the prime consideration—in telephone, television and radio service, and in the many types of electronic equipment where power consumption must be low—and in stationary applications where continuous operation demands durability.



Model 31-F, 5 reed, half cycle increment.

● the list of uses grows daily. Many are wartime uses which cannot be specifically mentioned. It can be said, however, that thousands of J-B-T Vibrating Reed Frequency Meters are protecting vital equipment where successful operation depends on constant or known frequency.

Model 30-F, double window, for ease in reading frequency in either range.

● these instruments are not affected by wave form, normal temperature change or external magnetic fields. Accurate to ± 0.3% or ± 0.2% depending on the model, and available for frequencies from 15 cycles to 420 cycles, for various voltages, and with several reed groupings and case sizes, full or half-cycle increment, sharp or broad response.

Model 53-F, 5 inch, 9 reed, for front-of-panel mounting.

Better requisition several ranges for your own use—they're so versatile, you'll wonder how you ever got along without them.

For details on the complete line of J-B-T Frequency Meters, send for Bulletin VF-43—and if interested in 400 cycle meters, also for VF-43-1A.

J-B-T

Model 60-FP, portable, covering four ranges.

(Manufactured under Triplett Patents and/or Patents Pending)

J-B-T INSTRUMENTS, INC.

431 CHAPEL STREET • NEW HAVEN 8, CONNECTICUT

12-JBT-6

both of the triode Hartley oscillator tube plates are fed through the headphones. When the beat note reaches the audible range the plate current impulses are heard in the headphones. The frequency of the pickup oscillator is kept slightly higher than the fixed oscillator frequency, to prevent the oscillators from locking into step.

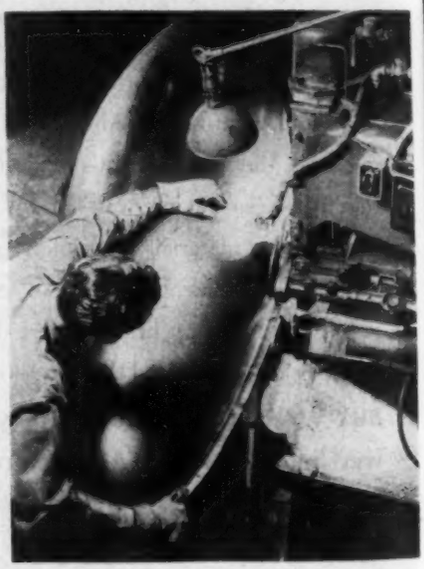
When a conductor comes into the field of the pickup coil the eddy current set up in the conductor opposes the field in the coil, and the effective inductance of the coil is reduced as a result of the "shorted-turn effect". The reduced effective inductance increases the frequency of the associated oscillator, and the audible beat note rises in pitch proportionally.

In actual operation the pickup oscillator frequency is set slightly high so that a low-pitched beat note is produced when the coil is about the correct distance above the street or barren soil level. Then, when a conducting body is approached, the beat note increases sharply in pitch, to a maximum directly over the conductor.

In the construction of such a locator it is important to shield the coil with metal foil or sheet metal, being careful not to form a short-circuited loop with the shield. Without a shield the capacitance of the pickup coil to

• • •

WELDING FOR WAR



Welding together the two halves of a droppable gas tank for military planes, using G-E resistance welding equipment. These tanks are used on flights beyond the normal cruising range, and are dropped when empty

THE PART YOU CAN'T SEE . . .

Nine-tenths of that iceberg is under water . . . the most important part is the part you can't see.

A lot of important parts are those you can't see. Thousands of them are making America's war machinery invincible . . . thousands more will make peacetime machines and appliances efficient, easy to use, and long lasting. They are parts of rubber, synthetic and natural, and they are essential in war and peace.

War demands have taught engineers and designers at Johnson Rubber a lot about precision . . . many of our parts today must be accurate in a way never known to the rubber industry before . . . and exacting needs make specifications rubber an accomplished fact.

Thousands of such small parts make the efficient, unbeatable operation of America's war machines possible . . . all Johnson Rubber production today is for Uncle Sam.

There will come a day, though, when we all have to think about transferring the boys' names from the honor roll to the pay roll, and getting back to our regular job of supplying a peacetime market. To meet that great day with a minimum of time waste is important to the boys coming back . . . and important to you.

Lay your plans now. Let us help you. Johnson engineers and designers can help you solve problems in your post war products . . . and come up with the right answers in the right kind of rubber in the specific part you need . . . and this precision in rubber perfected in wartime will serve you well in peacetime.

We will be ready to supply you when the time comes . . . but the time to think about it and plan ahead is now . . . not then.

The JOHNSON RUBBER CO. • *Middlefield, Ohio*

MOLDED & EXTRUDED RUBBER PARTS FOR INDUSTRY'S VITAL ASSEMBLIES

Indispensable in War—Essential in Peace

Since 1895

STILL MAKING GOOD AT SANBORN COMPANY

Given his first trial in 1935, this mighty midget immediately won many laurels for himself and Sanborn Company by making possible the first of several types of vacuum-tube electrocardiographs which have been recognized by the medical profession as leaders in their field.

This first successful coordination of electronic possibilities and Sanborn engineering skill proved valuable groundwork for present day assignments of war communications instruments, where once again the amazing energy of this workman is bringing new distinction to Sanborn Company.

Giving support to the wartime use of his unlimited imagination are fully-equipped machine shop, assembly facilities, and testing laboratories which had been already accustomed to working to strict requirements as a result of experience in meeting the necessarily exacting demands of the medical profession.

The electron tube has become the most valuable worker at Sanborn Company, not only for past and present accomplishments, but for the future of his versatile potentialities.

SANBORN COMPANY

MAKERS OF ELECTRONIC INSTRUMENTS

CAMBRIDGE 39, MASS.

Research, development, and production of electronic-mechanical instruments of precision which include communications war devices and medical diagnostic equipment. Openings in production schedules are occasionally available for new electronic problems.

Checking over-all performance of Command Set Transmitter

Know instantly **whether you are getting maximum efficiency from your UHF equipment with the ERCO MW-60 RESONANCE METER**

This dependable, sensitive, rectifier type vacuum tube voltmeter indicator provides a convenient and accurate means of checking transmitter performance in the 120 to 600 MC range.

Ideal for maintaining peak efficiency of:

Absolute Altimeters	Airport Traffic Control
Blind Landing Markers	Weather Teletype
Glide Path Markers	Broadcast Relay Circuits

The broad demand for the MW-60 is typical of the recognition of ERCO radio communications equipment by Government Departments; radio, aviation, and other industries. Inquiries invited from organizations planning post-war developments. Literature upon request.

ERCO

ERCO RADIO LABORATORIES INC

HEMPSTEAD, NEW YORK

Manufacturers of CUSTOM BUILT RADIO APPARATUS

the earth or vegetation creates a d crease in frequency so the result is tendency to cancel the frequency i crease caused by proximity to a co ducting mass. The fixed oscillat should be shielded, so the two osci lators will not be magnetically coupled.

The circuit shown in Fig. 6 elim inates the interlocking difficulty by the use of a form of buffer stage. A meter can be added to give visual in dication of buried metal, but head phones allow the operator to use his eyes in searching for traces of the lost object and to watch for traffic and obstacles. A meter would re quire at least one additional tube with increased battery drain.

Two-Unit Radio Balance Locator

A radio balance uses a modulated r-f transmitter and a separate re ceiver, each section having its own loop antenna. The antenna is wound in the edge of each unit, and com ponent parts and batteries are con tained within the loop.

The receiver and transmitter loops are supported at approximately right angles to each other by a frame. The adjustment is made by setting the re ceiver loop to the null point while the locator is held over barren ground. When a metallic object comes within the field of the transmitter, the field is distorted so that the receiving loop is no longer in exactly the null posi tion.

For pipe locating, such an instru ment works where it is impossible to make a physical connection to the pipe. For this use the transmitter and receiver are sometimes separated and operated as two units, the transmitter being used to induce a signal in the pipe. The receiver picks up the secondary radiated signal as the receiver is carried along the pipe.

—◇—

PHOTOTUBES, goniometers and special integrating chambers were used by Dr. F. H. Pough of the American Museum of Natural History to substantiate advertising claims of a New York City department store that facets cut around the girdle of a diamond give extra brilliance. (Most diamonds have rough girdles). He reported a "measurable" increase in brilliance.

THIS PRECISION DEVICE IS "MASS PRODUCED" BY MAGNAVOX

Magneto-Dynamic Speaker for military headphones— a "miniature loud speaker."

ACTUAL SIZE

THERE'S QUITE a contrast in size between this tiny speaker and a conventional 15-inch radio speaker. Yet Magnavox makes both—along with numerous other items of military equipment, ranging from solenoids to the most intricate types of complete radio communication systems.

A very high degree of precision is required to get maximum efficiency in so small a space. Though this device is made with almost "jeweler's" precision... containing windings finer than a human hair... it is turned out by mass production methods through the skill of Magnavox engineers.

Magnavox brings to the war effort the skill and "know how" developed by 32 years of designing, engineering and manufacturing for the radio industry, plus the splendid facilities of the completely modern new six-acre plant, finest machine tool equipment and the production economies of efficient management. The Magnavox Company, Fort Wayne 4, Ind.

Magnavox skill and craftsmanship won the Navy "E" in 1941, among the first awarded... now with 3 White Star Renewal Citations.

FOR 32 YEARS **Magnavox** HAS SERVED THE RADIO INDUSTRY

LOUD SPEAKERS • CAPACITORS • SOLENOIDS COMMUNICATION & ELECTRONIC EQUIPMENT

NEWS OF THE INDUSTRY

German communications equipment; new officers for IRE; post-war transmitter reservations; condition of mica stocks; television broadcasting association proposed; WPB plans for increased production

New Data on Captured German Radio Sets

OFFICERS OF THE Signal Corps returning from the fighting fronts in North Africa, Sicily and Italy are piecing together a picture of the present German radio communications on the basis of captured equipment. The over-all picture, according to those officers, appears to indicate that, generally speaking, Germany has standardized her equipment on the basis of developments in the period 1934-38, and the sets in use today are five years behind our own.

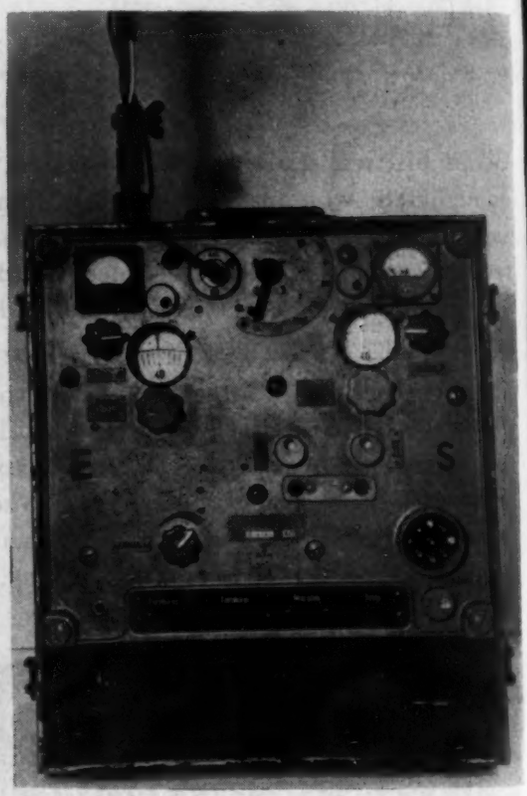
German apparatus is well-built and strong, but inferior to ours in design, components and construction. There has been no attempt to adapt German sets to the different conditions that exist in the countries in which they are to be used. For example, Captain James F. Lipp, Signal Corps officer recently returned from Africa, reports that the German sets tested lacked waterproofing and were not dust-proofed. Tape and crude sealing compounds were used in an attempt to make them resistant to corrosion and to exclude dust.

Standardization and simplification of German electronic equipment has been accomplished at the expense of both efficiency and amplification. The Germans use only 21 military types of tubes for a whole infantry division and a squadron of aircraft, whereas we have found that four times that number of tubes are needed to establish efficient communications and to obtain proper amplification. The Germans use operators with far less skill than ours. They are able to do so, with their simpler set-up. They have color coding on each tube and also letter coding, so that inexperienced communications personnel can be employed. A dot on a socket is matched by the same on a certain tube.

Sea Rescue Transmitters

In addition to the generally obsolete nature of the captured German equipment as compared with ours, the sea rescue transmitters taken from German planes recently have been inferior in design and quality to the type previously used, according to Captain E. A. Whitehead, Officer in Charge of Enemy Equipment, War Dept. This may well indicate

German 100-watt, 3-tube transmitter for use in vehicle or as fixed station in division command net, on frequencies from 200 to 1200 kc. No crystal control. May be used for CW or phone, local or remote keying, or for picture transmission. Manufactured by Lorenz as military version of a commercial design



German transceiver serving as infantry pack set for regiment-to-batallion-to-company communication. Antenna is 12-ft. vertical aluminum rod, with counterpoise spreaders to increase radiation to aircraft

a tightening raw material situation. The "notsender," which is the German version of our "Gibson Girl" automatic radio transmitter, is appearing in a small throw-away type, good, at most, for two days. Instead of the electron-alloy case, it is in a plastic case about the size of our handie-talkie. The new transmitter measures 6½x6½x3 inches instead of 10½x9½x9 inches, the size of the older German model.

The range of the new set is half that of the older set; it only has a 5-foot antenna. The batteries have only about 4 hours life. The power output is a fraction of a watt as compared with 6 watts. This cheap model has one tube instead of two. The wire used is corrosion-resisting steel whereas the other transmitter used pure aluminum "litz" wire.

The new transmitter is known to be in mass production and since none of the older models have been captured recently, it seems likely that this transmitter has replaced it. The sea rescue device is pre-tuned to the international distress signal channel. When an aviator is forced down, the German model is parachuted to the ocean, where it floats. A transmitter with such a short life as the new "notsender" definitely limits the time in which rescue is possible. It hardly seems likely, authorities surmise, that such an important safety device would be cheapened unless materials were on the short side.

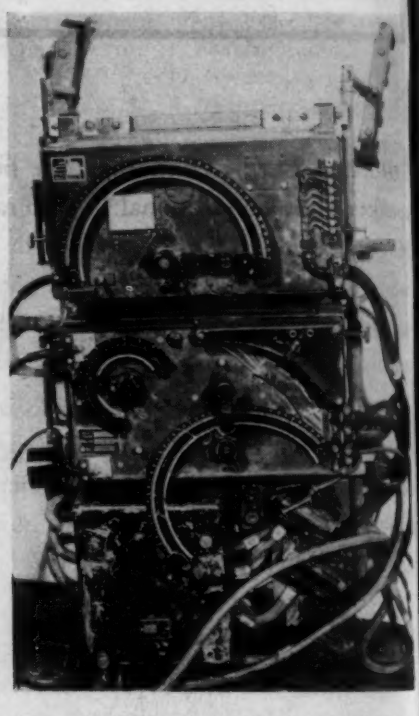
German airborne transceiver used by single-seat fighters for communication. Both transmitter and receiver have four preset frequencies in range from 38.6 to 42.2 MHz (Mc), without crystals, with provisions for remote fine tuning in the air. Transmitter uses two RL12P35 pentodes, and superheterodyne receiver uses nine RV12P2000A high-frequency pentodes variously connected as diodes, triodes and pentodes. Note manner of designating the four frequency settings by I, II, a triangle and a square

Another possible indication of shortages is found in the standard tubes used in equipment for armored cars and for airborne equipment. These were mounted in rubber in the old sets, but now they do not have the rubber mountings.

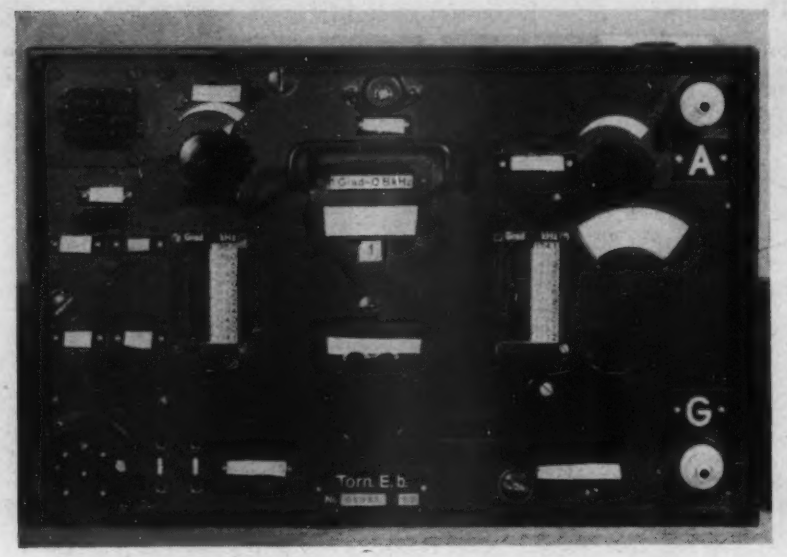
Calibration With Crystal Resonator

A rather unique type of frequency calibration is incorporated in one German pack transmitter.

In American radio equipment, calibration is usually accomplished by means of a crystal-controlled vacuum-tube oscillator which can be set to zero-beat with the transmitter carrier wave at the crystal frequency



The original radio installation for fighter planes, used in ME109F and Ju87 fighters for plane-to-plane and plane-to-ground communication. It is set to one frequency (around 3 Mc) on the ground. For voice only. Sometimes carried loose in planes on special missions. Captured unit shown is damaged



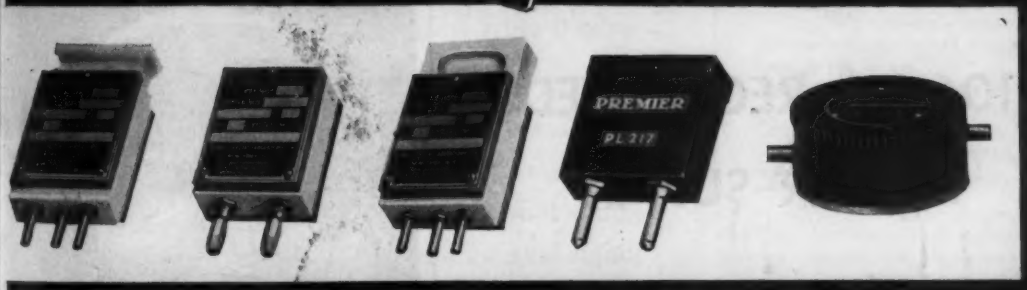
One of the most widely used portable receivers in the German army, tunable over 8 bands covering all frequencies from about 100 kc to 7 Mc. Contains four RV2P800 knob-type pentodes in tri circuit. Operates from vibrator unit and 12-volt battery or from dry batteries. Easily operated by our troops immediately after capture. Die-cast alloy metal extensively used, with silvered mica trimmers, iron-core inductances, easily-serviced mechanical band switch and other advanced engineering features

Precision

CRYSTALS

Premier for 15 years has made it a practice to pioneer and create precision Crystals and Holders to meet the most exacting requirements.

It has been the Premier policy not to compromise quality, precision or workmanship. This policy Premier will maintain today and tomorrow as yesterday.



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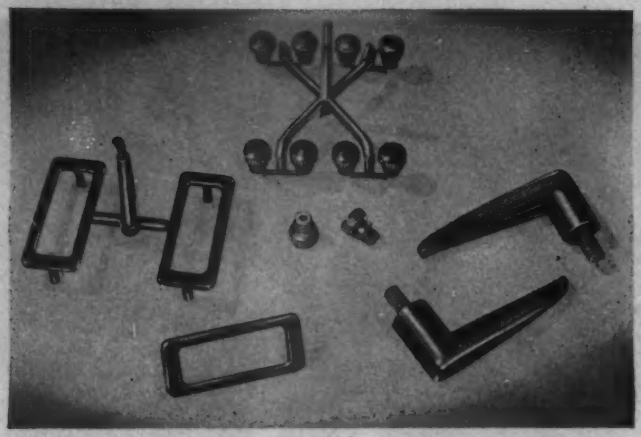

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SAVE METAL AND WOOD—
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Plastic is adaptable for manufacturing myriads of parts formerly made out of metal and wood. Usually plastic not only results in better looking parts, but also proves more economical to use.. Door handles, knobs, flashlight cases, plumbing fixtures—these are just a few of thousands of items now being made with plastic. No matter how difficult your problem may seem, there is a good chance it can be solved with plastic. Why not consult us?

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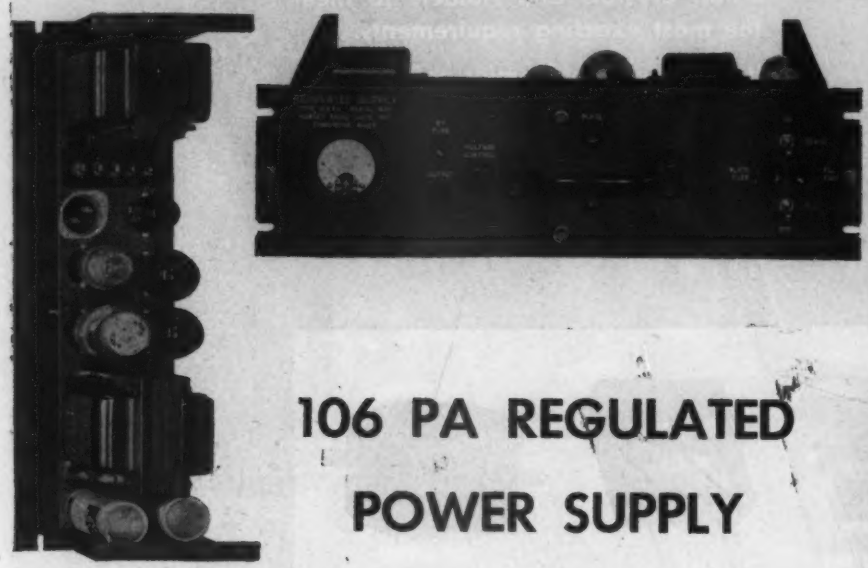

106 PA REGULATED POWER SUPPLY

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200 Volt to 300 Volt RANGE

A PRECISION INSTRUMENT FOR LABORATORY D.C. SOURCE

HARVEY *Radio Laboratories, Inc.*
445 CONCORD AVENUE • CAMBRIDGE • MASS.

Original "notsender", German version of hand-powered automatic 500-kc SOS transmitter for pilots forced down at sea. Only known example of crystal control in German aircraft radio. It is carried loose in aircraft, thrown in water, and picked up after emergency dinghy is floated. Small bag of hygroscopic material inside case removes moisture. (The American "Gibson girl" prototype was shown on the cover of Sept. ELECTRONICS.) Current German model is smaller, has plastic case, and is good for only about two days use

or a multiple thereof. The German transmitter utilizing the crystal resonator or calibrator uses a small built-in quartz crystal which bypasses a small portion of the radio frequency current from the final tank circuit to ground. The crystal is mounted on prongs within a partially evacuated tube. When the transmitter is exactly at the resonant frequency of the crystal, a distinct

This small, vacuum-type crystal resonator is used as a frequency calibrator for German pack transmitters

ELECTRONIC LIMIT BRIDGE

MODEL 670

FOR PRECISION RESISTANCE TESTING

Rapid precision resistance measurements can be made with this direct-reading Electronic Limit Bridge. The scale is uniformly calibrated from zero center to ten per cent deviation on either side. Each scale division corresponds to 0.5%. The instrument is furnished with one single value of built-in standard. The built-in standard can be any value specified from 8 ohms to 10 megohms.

Simplified direct readings in terms of ± deviations from a built-in standard of predetermined resistance. Provision also is made for the use of external standards of specified values. External and internal standards can be used in combination.

OTHER FEATURES OF THE MODEL 670 ELECTRONIC LIMIT BRIDGE ARE:

Component resistors are 0.1% accurate.

4½" Galvanometer.

Galvanometer has a sensitivity of 25 microamperes in either direction.

Engraved bakelite panel is heavily shielded.

Two 1C5GT type tubes are used in the circuit.

Battery operated.

Automatic cutout switch disconnects batteries when instrument is not in use.

Model 670 is supplied in a handsome, natural-finish, solid oak case, 14¾" high, 10¼" wide, 8½" deep. Weight 10¼ lb.

Code—FROAL

Complete with self-contained battery supply, ready to operate..... **$150**

Other instruments in the complete line of R.C.P. electronic and electrical instruments described in Catalog No. 126. If you have an unusual test problem—either for production or laboratory work—our engineers will be happy to cooperate in finding the most efficient solution.

REASONABLE DELIVERIES ARE NOW BEING SCHEDULED

RADIO CITY PRODUCTS COMPANY, INC.

127 WEST 26th STREET — NEW YORK CITY

MANUFACTURERS OF PRECISION ELECTRONIC LIMIT BRIDGES — VACUUM TUBE VOLTMETERS — VOLT-OHM-MILLIAMMETERS — SIGNAL GENERATORS — ANALYZER UNITS — TUBE TESTERS — MULTI-TESTERS — OSCILLOSCOPES — AND SPECIAL INSTRUMENTS BUILT TO SPECIFICATIONS

Photograph taken at Sperry Gyro-Compass School

The United Nations go to school

THE OWNERS of those hats are learning about the Sperry Gyro-Compass the practical way. These representatives of the United Nations are seeing it in action in the Sperry Gyro-Compass School.

Many of the men who own those hats will be on convoy duty soon. They already know the risks of submarine warfare and surface contact. They know that lighthouses are dark these perilous nights, that radio beacons are silent, lightships are gone, weather reports no longer available, and even the use of radio communications rigidly limited.

And they know they may sail in prefabricated hulls built under conditions involving immense variation in residual magnetism. Their cargoes may be highly magnetic and their ships almost certain to be equipped with degaussing apparatus to render ineffective the sensitive magnetic mines that lurk in their path.

These factors spell the need of attaining absolute precision in navigation and call for navigation equipment that is impervious to profound and diverse magnetic influences.

That is why these sea-going men are learning about the Sperry Gyro-Compass and why it is more essential than ever in war time. In the course of their study, they learn too that the substitution of electronic circuits* for roller contacts in the follow-up system of the new compass assures even greater reliability with less care and maintenance than before.

When these men pick up their hats for the last time in the Sperry Gyro-Compass School and board their ships, it will be with full knowledge of and confidence in the Sperry Gyro-Compass.

* The Sperry electronic Gyro-Compass is sometimes called the Sperry *Gyrotronic* (registered trade-mark) Compass.

SPERRY

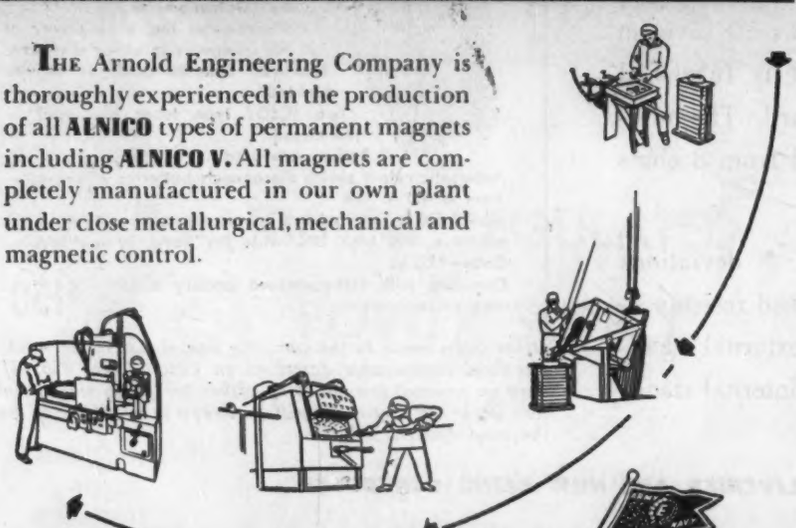
GYROSCOPE COMPANY, INC.

Brooklyn, New York

Division of the Sperry Corporation

PERMANENT MAGNETS

THE Arnold Engineering Company is thoroughly experienced in the production of all **ALNICO** types of permanent magnets including **ALNICO V.** All magnets are completely manufactured in our own plant under close metallurgical, mechanical and magnetic control.



THE ARNOLD ENGINEERING COMPANY
147 EAST ONTARIO STREET, CHICAGO 11, ILLINOIS

Commercial type German receiver used for entertainment and propaganda reception purposes at rear. Frequency range is 150 kc to 15.8 Mc. It uses five metal tubes, and operates from a variety of power sources. The following notice is printed in German on the carrying case: "WARNING! Use of this radio for foreign station reception is a crime against the national safety. By order of Der Fuhrer such use will be punished with severest penalty. SOLDIERS, BEWARE!"

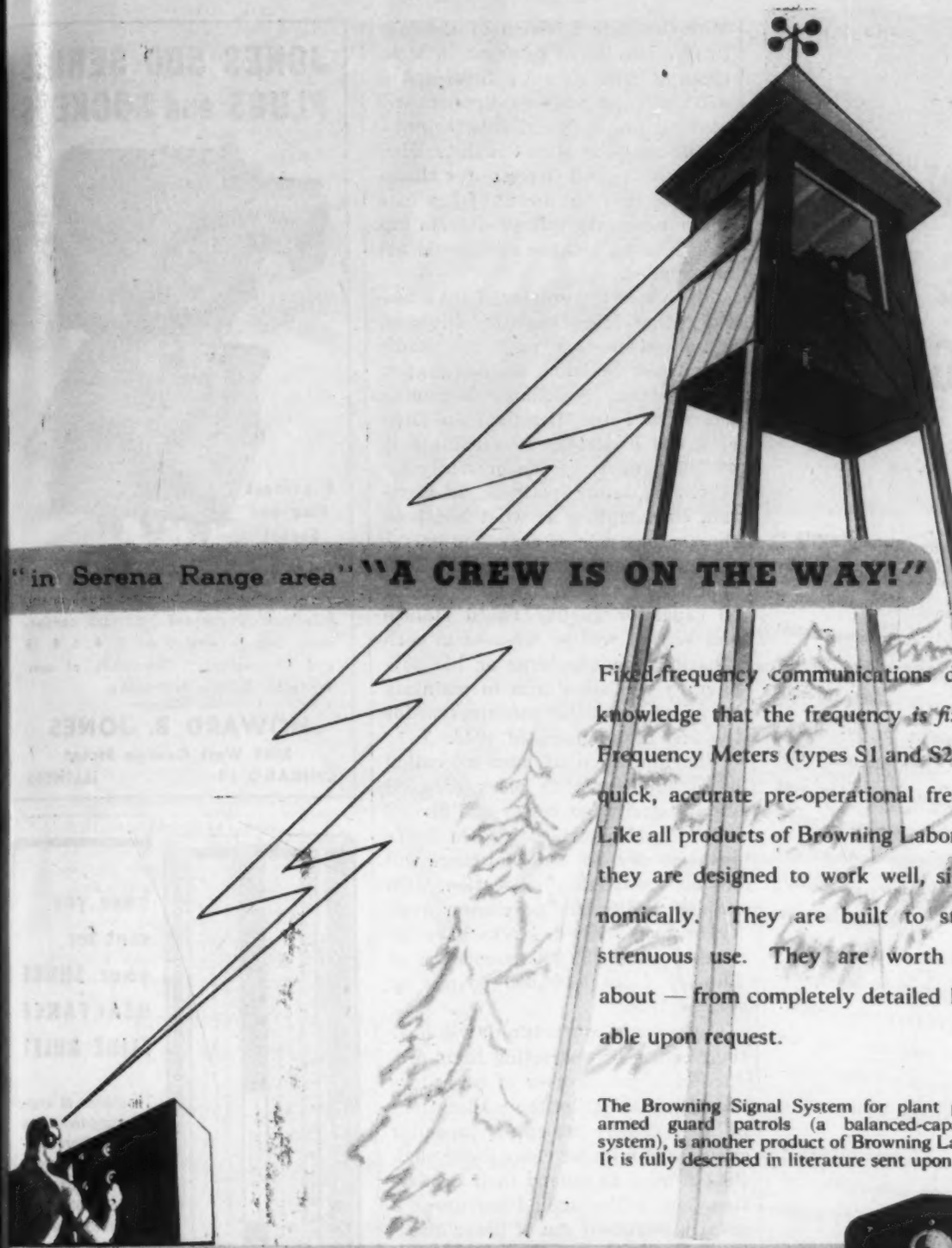
luminescence is produced in the tube. So that this indication can be even more readily seen, a small amount of neon gas is introduced which gives a characteristic pink glow.

This method of calibration is not as accurate as our conventional type, but it does result in a decrease of space, components and power requirements in the pack sets.

Germans Designed Italian Sets

Italians developed radio sets almost identical with those of the Germans. It has been learned that German technicians were brought into Italy. They used Italian industrial equipment to design apparatus in the German way. However, instead of using German tubes, Italians used tubes originally made under American and British patents, and followed circuits which are also of American design. Italians did not have sufficient facilities and materials, and hence their sets are reported to be inferior not only to ours but also to the German sets.

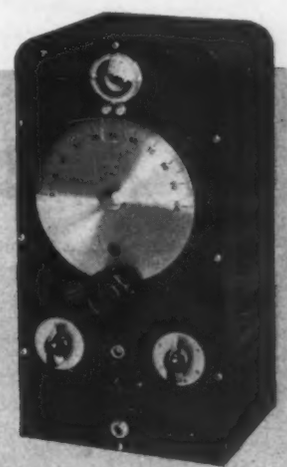
The Germans find it impossible to



"in Serena Range area" "A CREW IS ON THE WAY!"

Fixed-frequency communications depend on sure knowledge that the frequency *is fixed*. Browning Frequency Meters (types S1 and S2) make possible quick, accurate pre-operational frequency checks. Like all products of Browning Laboratory research, they are designed to work well, simply, and economically. They are built to stand up under strenuous use. They are worth learning more about — from completely detailed literature available upon request.

The Browning Signal System for plant protection without armed guard patrols (a balanced-capacitance electronic system), is another product of Browning Laboratory research. It is fully described in literature sent upon request.



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Compact, SHOCK-PROOF RELAYS
GIVE OUTSTANDING PERFORMANCE
The outstanding performance of SP relays have gained wide acceptance in communications equipment, radio equipment, aircraft equipment and other essential applications where a small, compact, shock proof general purpose relay can be used. SP relays are available in both AC and DC types.
WRITE FOR NEW DESCRIPTIVE CATALOG
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THE POSITIVE ACTION RELAY

PRECISION TO THE "Nth" DEGREE
Perfect co-ordination of skilled minds and hands in a well knit organization with 20 years of radio manufacturing experience has been the secret of MERIT'S success in building precision equipment to the most exacting specifications.
Now manufacturing for every branch of the Armed Services.
Suppliers of component parts for the famous SCR-299 mobile unit.
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Transformers — Coils — Reactors — Electrical Windings of All Types for the Radio Trade and other Electronic Applications.
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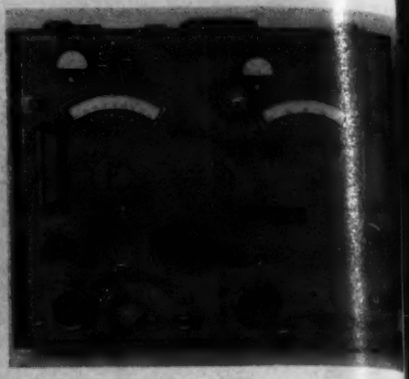

German transceiver for field service as a pack set. Uses a "leuchtquartz" crystal resonator sealed in a gaseous tube for calibration only, and operates from a 2-volt wet battery and two 90-volt dry batteries, with power output of about 0.65 watt for CW or phone on two preset frequencies around 4 Mc

make use of the Italian equipment because their tubes do not fit in the sets. On the other hand, Italian radio equipment may be utilized by the Allied Nations as soon as it is taken over. We can use it in its entirety or in part. For repairing sets, all enemy radio equipment is cannibalized for coils, capacitors, resistors, tubes, batteries and meters.—G.T.M.

WPB Acts on Mica Conservation

USERS OF HIGH-QUALITY MICA have been notified that the War Production Board will undertake to provide only sufficient quantities of the better grades of mica to maintain consumption at the average rate maintained during the first nine months of 1943. This policy becomes effective during December.

The average consumption of good stained mica and better qualities for the first eight months of this year has been more than 50,000 pounds above receipts. This has seriously depleted Government stocks of certain types of mica used in capacitors. In most cases industry stocks are also reduced to a minimum working inventory.

There are six types of mica of which supply is shortest. They are: No. 4 clear and slightly stained block, No. 5 fair stained block, No. 5½ fair stained block, No. 5½ good stained block, No. 5 fair stained film, and No. 5½ fair stained film. All of these are used almost entirely for mica capacitors. The insufficiency of these types of mica has compelled the

WHEN THERE IS AN EMERGENCY

The more than twenty years of intensive research conducted by Meissner engineers has been a vital factor in overcoming almost insurmountable objects in the production of precision-engineered parts for our armed forces . . . an electronic unit order recently rejected by over half a hundred manufacturers was accepted and put into production by Meissner engineers . . . their vast experience combined with Meissner's modern manufacturing methods produced this emergency war-time unit for a special electronic application.

All Meissner products are precision-built . . . a good reason why engineers specify Meissner.

Meissner

MT. CARMEL, ILLINOIS

"PRECISION-BUILT ELECTRONIC PRODUCTS"

Mica-Graphite Division of the War Production Board to draw on other types of mica as substitutes and it will not be long before suppliers will be unable to meet demands for mica. Up to now the Mica-Graphite Division has filled all requests for allocation and it is not aware of any case where necessary war production has been held up because mica could not be supplied.

In view of the gravity of the situation, the Mica-Graphite Division, after consultation with the Radio and Radar Division, decided that in the future, probably beginning December 1, the Mica-Graphite Division will undertake to provide only sufficient mica, of the presently accepted capacitor qualities, to maintain consumption at what has been the average rate of consumption for the first nine months this year. Such quantity of mica of presently accepted capacitor quality (good stained and better) will be released to each capacitor manufacturer or his supplier as will allow him to maintain his average monthly consumption for the first nine months of 1943.

The limitation of mica allocation is to apply only to block of good stained quality or better and film of second quality or better. On lower qualities of block and film there will be no restriction allocation. On stained quality, the next lower quality to good stained, stocks have increased from 370,000 pounds as of January 1, to 1,160,000 pounds on August 1.

Capacitor manufacturers will have their choice of restricting their production to the number of capacitors they can make from their allocations of the usually accepted capacitor qualities of mica, or using lower qualities of mica to expand their production. This policy should encourage a greatly increased use of lower qualities of mica for capacitors.

The system will be subject to revision quarterly, at which time the ratio of new allocation for capacitor production may be increased or decreased, depending on the receipts of mica in the Government stockpile during the preceding quarter.

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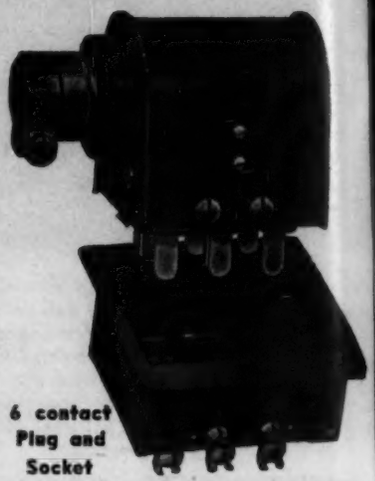
CLINICS for adjustment and cleaning of electric motors are provided by the New York State College of Agriculture as a service to farmers.

JONES 500 SERIES PLUGS and SOCKETS



6 contact Plug and Socket

5000 volts and 25 amperes. Fulfills every electrical and mechanical requirement. Polarized to prevent incorrect connections. Easy to wire. Sizes: 2, 4, 6, 8, 10 and 12 contacts. Thousands of uses. Write for Bulletin 500 today.

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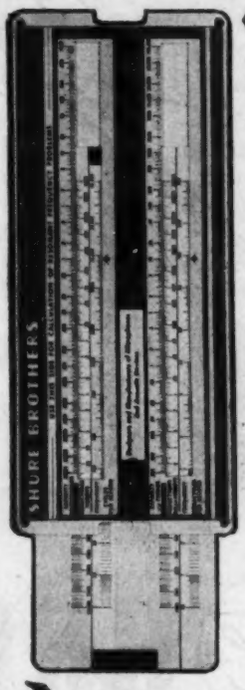

have you sent for your SHURE REACTANCE SLIDE RULE?

Thousands of engineers and technicians find the Shure Reactance Slide Rule helpful in radio computations. Simplifies problems in resonant frequencies, circuits, inductances, condensers. Range 5 cycles per sec. to 10,000 megacycles. Complete with instructions. Send 10c in coin to cover handling.

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225 W. Huron St., Chicago
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Designers and Manufacturers of Microphones and Acoustic Devices

SHURE MICROPHONES

ADLAKE *Plunger-type* MERCURY RELAYS

Snap Action

That Stays "Snappy"!

Adlake Model 1040
For panel mounting. This relay can be supplied with either quick or time delay action; normally open or closed; and for a.c. or d.c. energization. Contact ratings up to 100 amperes a.c. with proportional d.c. ratings.

MERCURY moves *fast.* You know that because you've seen it in action. Due to this inherent characteristic of mercury, Adlake plunger-type *mercury* relays provide the *snap action* so desirable in a relay when contact is made—or broken.

There is positively no tendency toward "molasses in January" operation in these relays. Their action is "snappy" and it *stays "snappy"!*

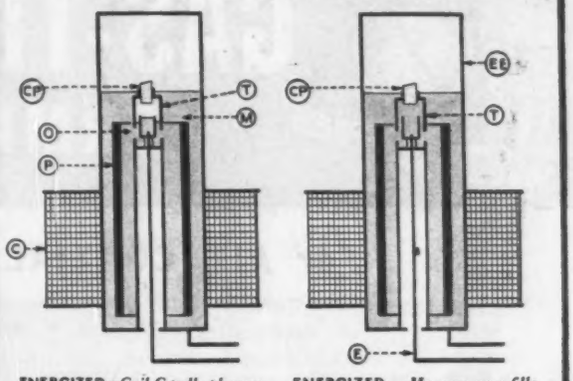
Hermetically Sealed Contact Mechanism

Contact mechanism of Adlake plunger-type mercury relays is hermetically sealed in an *armored* glass or metal cylinder. Dirt, dust, moisture, or oxidation cannot interfere with operation—*in any way or at any time.*

The *liquid* metal mercury contact is positive in action, chatterless, silent, and impervious to burning, pitting, and sticking.

For many kinds of service, no other type of relay provides equal *stamina* and *dependability.* Request complete bulletin.

HOW THEY WORK



ENERGIZED—*Coil C pulls plunger P down into mercury. Mercury thus displaced enters thimble T through orifice O. Inert gas in thimble gradually escapes through ceramic plug CP—thus producing time delay.*

ENERGIZED — *Mercury now fills thimble T, is completely leveled off and mercury-to-mercury contact established between electrodes E and EE. Degree of porosity of ceramic plug CP determines length of time delay.*

Adlake TRADE MARK

THE ADAMS & WESTLAKE COMPANY

ESTABLISHED IN 1857 — ELKHART, INDIANA — NEW YORK · CHICAGO

MANUFACTURERS OF ADLAKE SPECIALTIES AND EQUIPMENT FOR RAILWAY, AIRWAY, HIGHWAY, AND WATERWAY

For

EXCESSIVE VIBRATION

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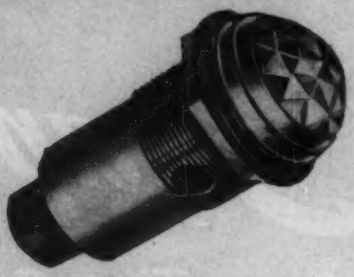
use

Gothard



MODEL 1006 PILOT LIGHT

This unit is ruggedly constructed with bakelite base and has bayonet catch shell type socket for standard automotive size lamps. Mounts in hole 1" dia. and is designed for use on panels up to ⅜" thick. Special lamps for thick panels can be furnished. Jewels: faceted, plain, or frosted plain. Colors: red, green, amber, blue, opal or clear.

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Ask for complete specifications.

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The new Andrew glass insulated terminal is an outstanding development that provides you with a 100% *air-tight, gas-tight* system for gas filled coaxial cables. Permanent, leak-proof operation of Andrew terminals is insured because of a unique design using a glass-to-metal seal. A special design that minimizes shunt capacity makes them ideally suited to high frequency operation. Dielectric losses are reduced over the standard ceramic type insulated terminals because of reduced volume of glass in regions where the electric field is greatest.

The Andrew Company is a pioneer in the manufacture of coaxial cables and other antenna equipment. The entire facilities of the Engineering Department are at the service of users of radio transmission equipment. Catalog free upon request.

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Industry Advisory Committee for Mica Capacitor Conservation

AN ADVISORY COMMITTEE to deal with conservation was formed in October for the mica capacitor industry by WPB. The committee is composed of a government presiding officer, E. R. Crane, and committee members: G. M. Ehlers of Centralab, Inc.; Jack Davis, Galvin Mfg. Co.; T. M. Gordon, Radio Receptor Co.; M. R. Johnson, General Electric Co.; Bryce Minnium, Erie Resistor Co.; Dorman D. Israel, Emerson Radio & Phonograph Corp.; Herbert L. Spencer, Bendix Radio Corp.; F. E. Hanson, Western Electric Co.

Mass Production of Quartz Crystals

THE MUSHROOM GROWTH and development of the quartz crystal industry has been one of the major victories won on the home front by science and technology.

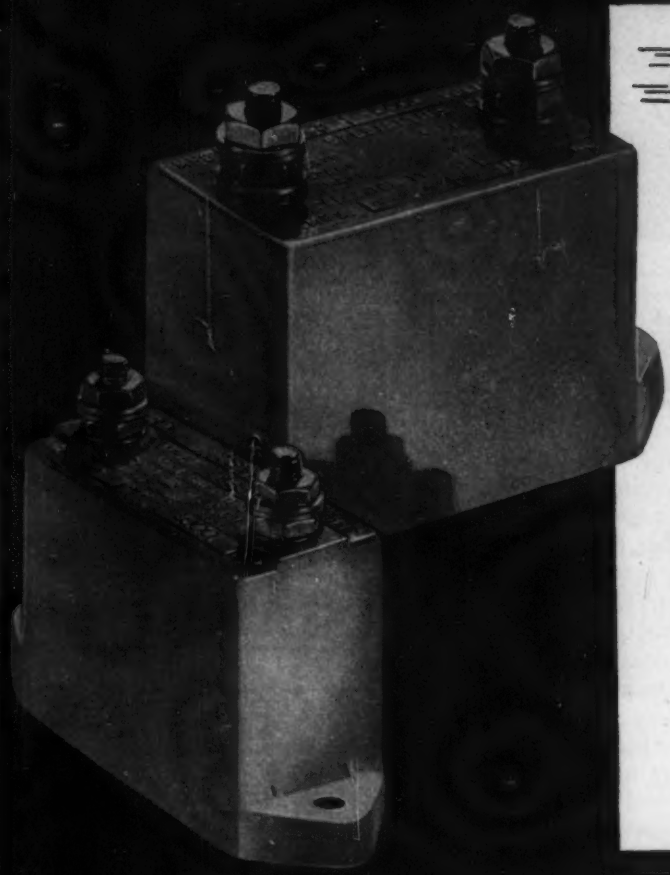
Less than two years ago, quartz crystals for radio equipment were made under laboratory techniques, starting with the rough natural quartz and fashioning the complete crystal one at a time, in much the same fashion as a master craftsman cutting a diamond.

A new, thin type of diamond saw permits a greater number of slabs to be cut from the mother crystal. The crystal is cemented to a base so that the saw cuts through the adhesive and the crystal

On this industry, totally unequipped for mass production, the sudden, overwhelming need of quartz for war use descended in April, 1942. It has been estimated that, using techniques then in use, it would have taken all the quartz-crystal techni-

MOLDED-CASE POTTED MICA CAPACITORS

Made to American War Standard Specifications



fast deliveries

Need medium-power mica transmitting-type Capacitors to match today's exacting specifications? Then write for details—or samples—on Types CM-65 (Sprague MX-16) and CM-70 (Sprague MX-17). These sturdy units are specifically designed to meet American War Standard requirements for Capacitors of this type and, as of the date this message is written, deliveries are surprisingly prompt, thanks to Sprague's greatly increased plant capacity.

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NORTH ADAMS, MASS.

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CAPACITORS
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Reference Book & Buyer's Guide *Free*

Industrial users of radio and electronic tubes, parts and equipment will find this big, costly volume an indispensable technical and buying aid. It lists thousands of products by hundreds of manufacturers. Write for your copy on company's stationery, please.

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311 S. WESTERN AVE., CHICAGO 12, ILL.
Phone CANal 2525

Dry ice test chamber is used to test crystals under temperatures as low as minus 10 deg. C in the John Meck Industries plant at Plymouth, Ind.

cians in the world some fifty years to supply the crystals needed by the U. S. armed forces in 1943.

As a result, crystal manufacturers had to swing to mass production and use assembly line techniques immediately. The Army Signal Corps cooperated, manufacturers were given the highest priority support, and a special procurement office was set up through which to get supplies.

Since machinery for making crystals was practically nonexistent, crystal producers had to design and fabricate their own equipment in an unbelievably short time. Soon new machines were produced and workers, who had never seen quartz, were trained to use them.

Then another problem was dumped into the laps of the crystal manufacturers. Suitable quartz could only be obtained in Brazil. Shipping facilities were strained so greatly that planes, on return trips from African war bases, stopped off in Brazil to bring capacity loads into this country.

Soon research workers came through with new cutting methods that allowed a greater number of slabs to be cut from the mother crystal. Salvage of formerly discarded inferior crystals for new special uses makes further economy possible.

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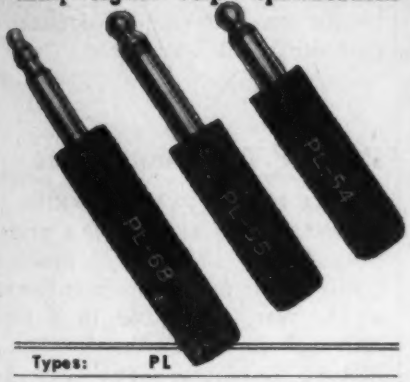
70 Types PLUGS & CONNECTORS

Army Signal Corps Specifications



Types:	PL			
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54	62	76	119	159
55	63	77	120	160
56	64	104	124	354
58	65	108	125	
59	67	109	127	
60	68	112	149	

PLP		PLQ		PLS	
56	65	56	65	56	64
59	67	59	67	59	65
60	74	60	74	60	74
61	76	61	76	61	76
62	77	62	77	62	77
63	104	63	104	63	104
64		64			

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REMLER DESIGNS AND MANUFACTURES tools and dies, plastic moldings and screw machine products for the trade and combines these products of its own manufacture into electronic devices and complete communication equipment. The skill, experience and services of this firm, which date back to the infancy of these industries, is available to those engaged in war production and peace-planning. Remler facilities and production techniques frequently permit quotations at lower prices.

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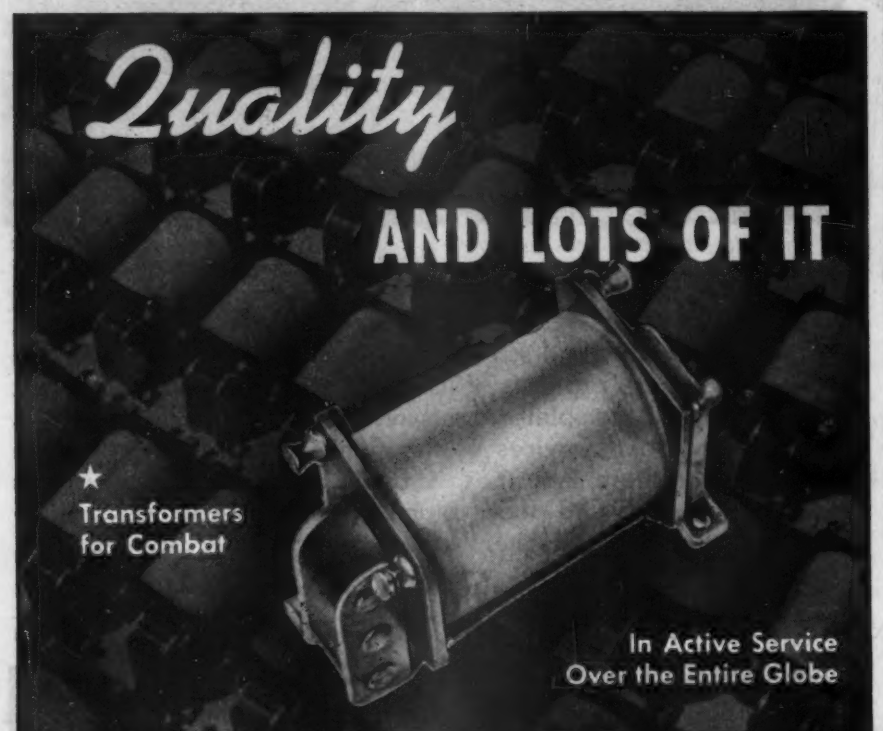

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In Active Service Over the Entire Globe

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Reserving Post-War Transmitters

A RESERVATION PLAN for the post-war purchase of radio broadcasting equipment has been inaugurated by General Electric Co. The plan supports the war effort and enables broadcasters to make definite reservations for equipment to be built and delivered as soon as conditions permit. It also permits G-E to prepare for an orderly transition from wartime to peacetime production and help keep workers at their jobs.

The plan applies to both AM and FM equipment and does not require a contract to buy. It operates by the broadcaster notifying the company as to the power of the transmitter he will need, then depositing with G-E the amount required in registered United States War Bonds. A priority will be assigned to the prospective broadcaster based on the time of mailing the reservation as shown by the postmark.

The income from the bonds on deposit goes to the broadcaster and title to the bonds remains with him. The bonds may be withdrawn at any time and the only penalty is loss of priority. The actual order for equipment can be placed at any time up to 90 days following the date when the production and sale of commercial transmitters is authorized.

Postwar Television Plans

A PLEA FOR POSTWAR PLANNING for television now so that the present state of the art can be presented to the public immediately at the end of the war, was made in a paper delivered to the Society of Motion Picture Engineers at the October convention in Hollywood by Klaus Landsberg, director of television at station W6XYZ, Hollywood, Calif. A summary of the paper follows.

If, at the end of the war, the returning soldiers, war workers and the public in general are not to be disappointed by a new delay of television due to differences in opinions regarding the technical form best suited for television, it is the responsibility of those active in television and those intending to enter the television field after the war to plan now. The television industry must plan, by itself, and with other industries which are affected by this new

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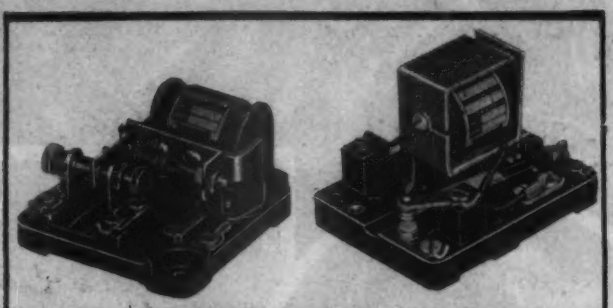

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While the availability of all XceLite Tools is limited, orders with satisfactory priority ratings can be filled. See your jobber or write Dept. C.

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medium. The creation of a radio technical planning board and its work must, therefore, be greatly appreciated and supported by the television industry.

In planning for television two questions are most outstanding: Have there been any developments that will revolutionize television and should color be incorporated into these plans? If revolutionary developments have been made they are not and cannot be known now. It is certain though that thorough experimentation and testing of such developments would be necessary. Time for this could not be found until after the war when the majority of qualified engineers, now occupied with more urgent tasks, can be released for this work. This would undoubtedly delay television for many years.

Demonstrations of color television have proven its possibility, but much work is required before it is simplified and foolproofed sufficiently to be put into use by the layman. Electronic means of color scanning must be developed.

All these considerations point to the necessity of deciding whether we should plan for immediate postwar television or for a later, maybe much later, time. To answer this one question we must ask several others. Above all whether television with its present standards and present state of the art can give a high quality service or not. I believe the experience of the past years enables us to answer with an emphatic yes! Television is ready to give an excellent service!

The quality of television pictures today is such that it can be compared to the quality of sixteen millimeter motion picture film. With improvement of circuit components and tubes for the transmitter as well as the receiver, particularly the improvement of camera tubes and cathode-ray receiver tubes, so much better quality of images can be obtained without a change in the system that it seems doubtful that different systems will become necessary.

The following facts appear to indicate that black and white television is ready now to give a highly adequate service with presently used standards and systems.

(a) War time mass production of similar equipment has shown the way

WHERE does Stackpole Molded Powder Metallurgy Fit into *YOUR* Picture?

. . . *it pays to know!*

Iron powders made from non-critical mill scale and ore, solidly molded to close tolerances represent an important source of easier-to-obtain and less costly components for a wide variety of products.

From molded gears, to pole pieces for small motors, magnetic yokes for circuit breakers, and iron cores, to large parts and unusual shapes where much machining is ordinarily involved, Stackpole Molded Powder Metallurgy is already outstandingly effective in many industries—and this is barely the beginning.

So far-reaching are the possibilities of these molded materials, it is safe to say that there are few products indeed wherein the possible use of such components should not be considered. Stackpole engineers welcome the opportunity to cooperate—and to tell you frankly whether or not Stackpole Powder Metallurgy methods may be of service.

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. . . also Fixed and Variable Resistors, Iron Cores, and Switches for the Electronics Industry

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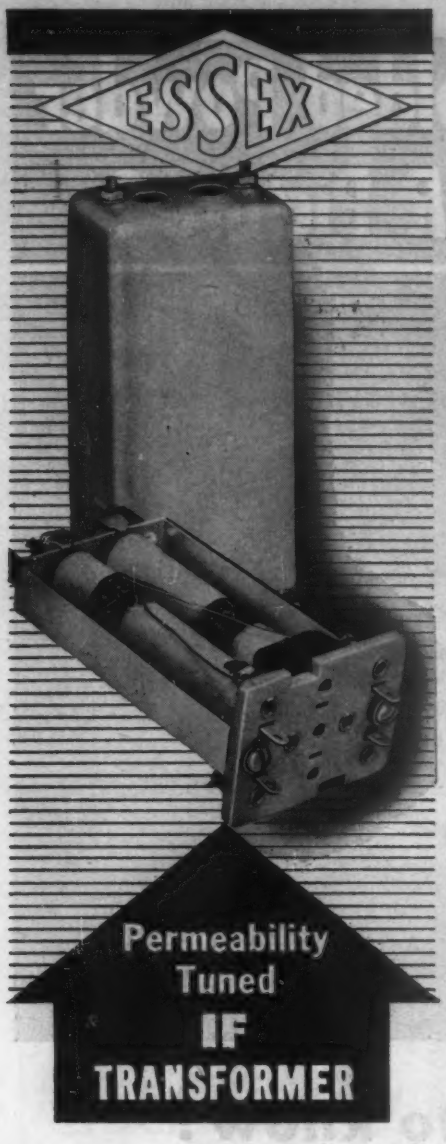

Manufactured in standard dimensions 1 7/8" x 1 7/16" x 4" seated height . . . for all frequencies in the range from 175 kc to 40 Mc . . . constant coupling . . . high selectivity . . . extreme stability due to use of ceramic parts and silver-mica condensers . . . all adjustments accessible from top.

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for production of television receivers below $100.

(b) Projection of high quality television pictures to theater screen size is no longer a laboratory dream.

(c) With new types of camera tubes no excessive light level is required for a television pickup.

(d) Through progress made in VHF transmitter tubes and antenna design a signal strength adequate to give practically interference free reception even in the poorest receiving localities can be produced.

(e) Relay transmitters make linking of cities and transcontinental television possible.

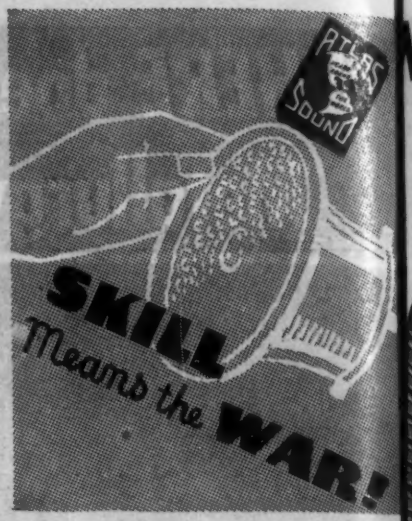
Undoubtedly the addition of color is desirable, but should be perfected and thoroughly tested prior to incorporation into standards and public service. Technicolor motion pictures, although highly perfected, have to this day not replaced black and white film.

Another consideration in television planning is the frequency band television stations should occupy. Television, I believe, would encounter difficulties in moving to higher frequencies where multipath tranmission becomes a more serious factor, since reflected signals are a greater hazard to picture transmission than to many other services. Still, television will require more room in the frequency spectrum and plans must be made to obtain it.

• • •

TELETYPE RECORDER

Admiral Nimitz inspects apparatus designed by Bell Telephone Labs for teletypewriter recording of electrical data at rate of 40 observations per minute. Each observation is a balancing operation



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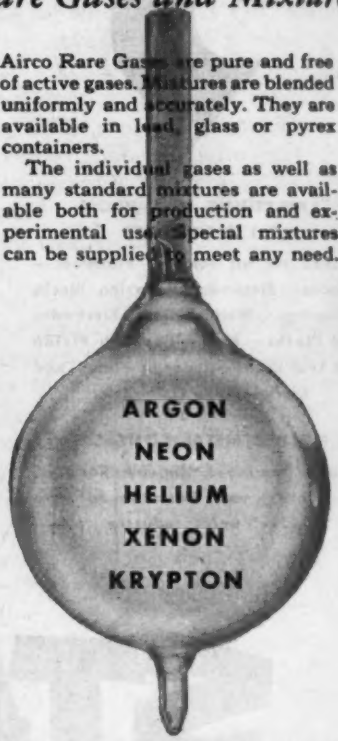

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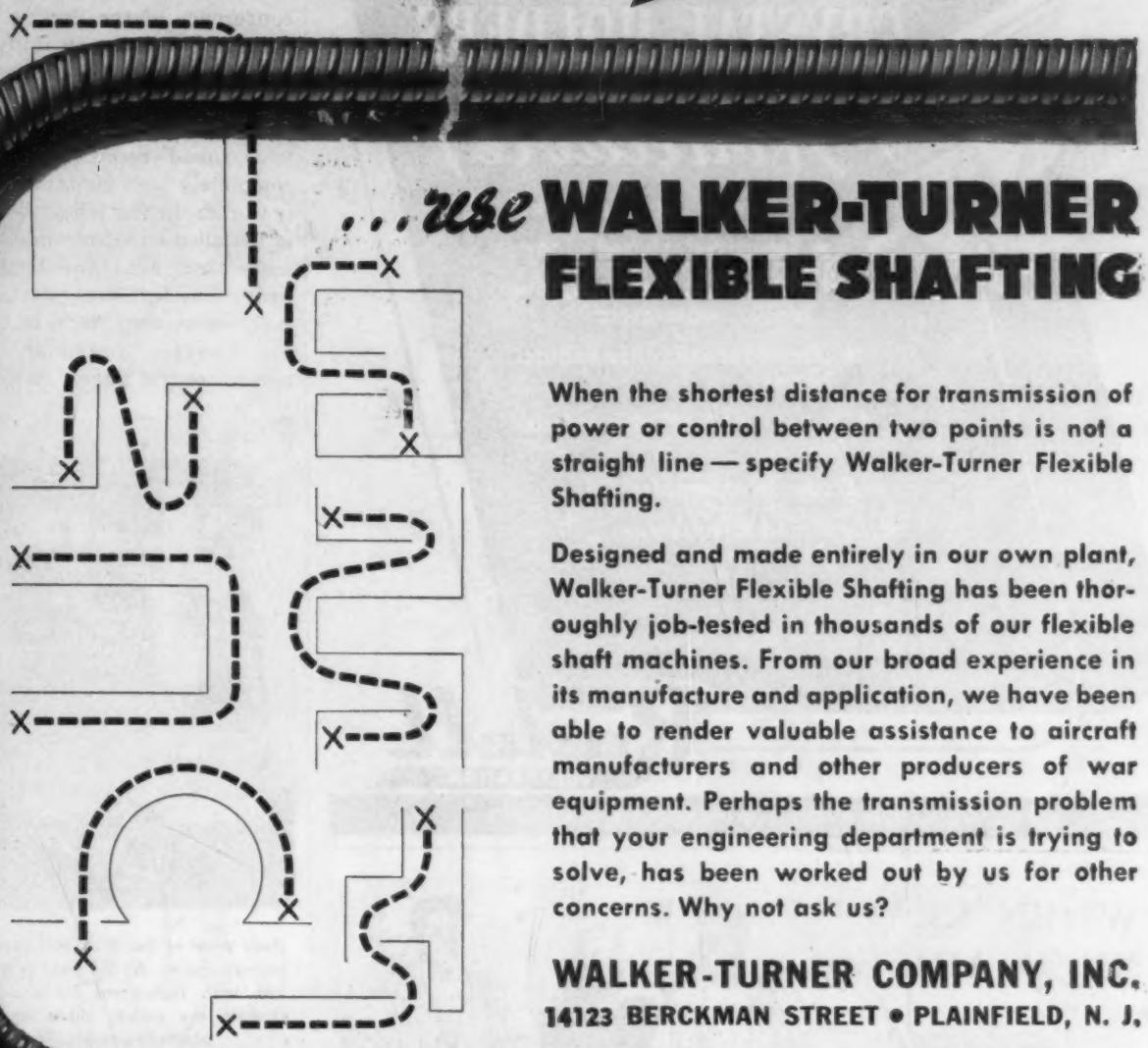
When the shortest distance is *NOT* a straight line



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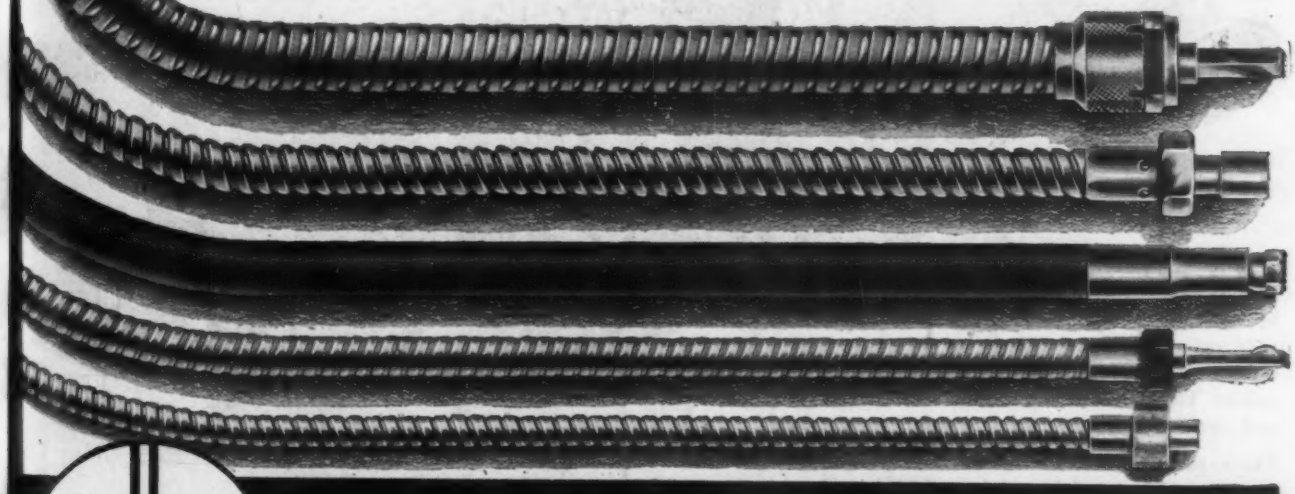

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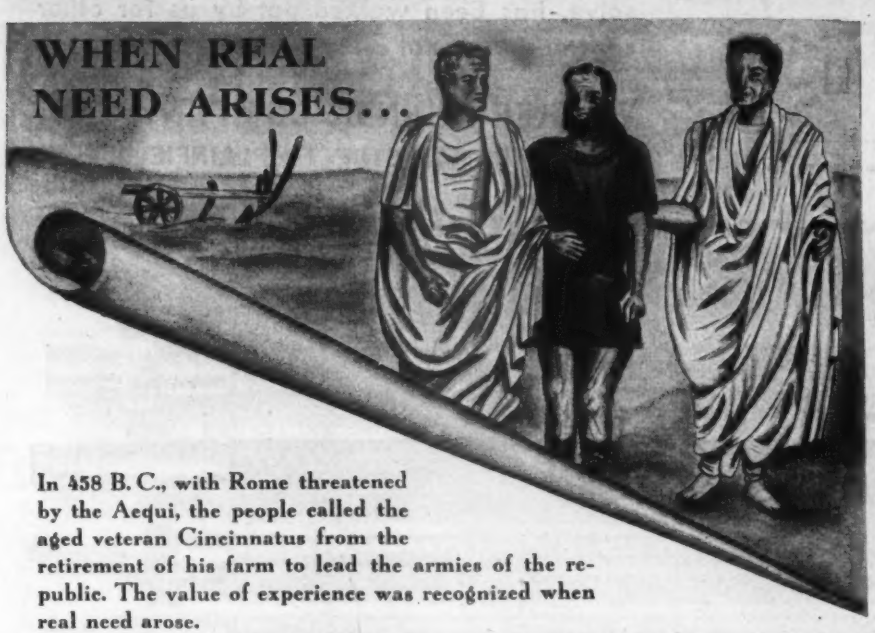


In 458 B. C., with Rome threatened by the Aequi, the people called the aged veteran Cincinnatus from the retirement of his farm to lead the armies of the republic. The value of experience was recognized when real need arose.

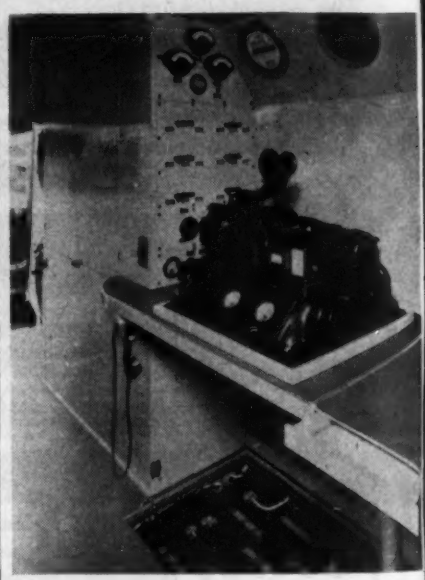
The experience of the ERWOOD engineering organization will be available to you after this war is won. Place ERWOOD first on your list of postwar consultants.

THE ERWOOD COMPANY
225 WEST ERIE STREET CHICAGO, ILLINOIS

Mobile Sound on Film

ONE OF THE PAPERS presented at the conference of the Society of Motion Picture Engineers in Hollywood during October was given by J. L. Fields, of the RCA Hollywood staff, and described a mobile motion picture sound recording unit that is completely self-contained and self-powered. In the truck the equipment is installed on either side of a center aisle that runs the length of the body. The facilities provided include a recorder, amplifiers, motor generator, B-supply dynamotor, cable reels, power control panel, monitor speak-

Rear view of the RCA self-powered motion picture truck. At the right is a dark chamber with light-proof sleeves. The reels contain the power cable and the microphone-to-preamplifier cable



The film sound track recording machine is located near the front of the truck. The trap door provides access to the batteries from inside the truck

The utilization of the electron through the agency of the vacuum tube is one of Ken-Rad's many contributions to the science of Electronics in war These electronic discoveries will be at the disposal of industry — in hundreds of developments — immediately after the Peace

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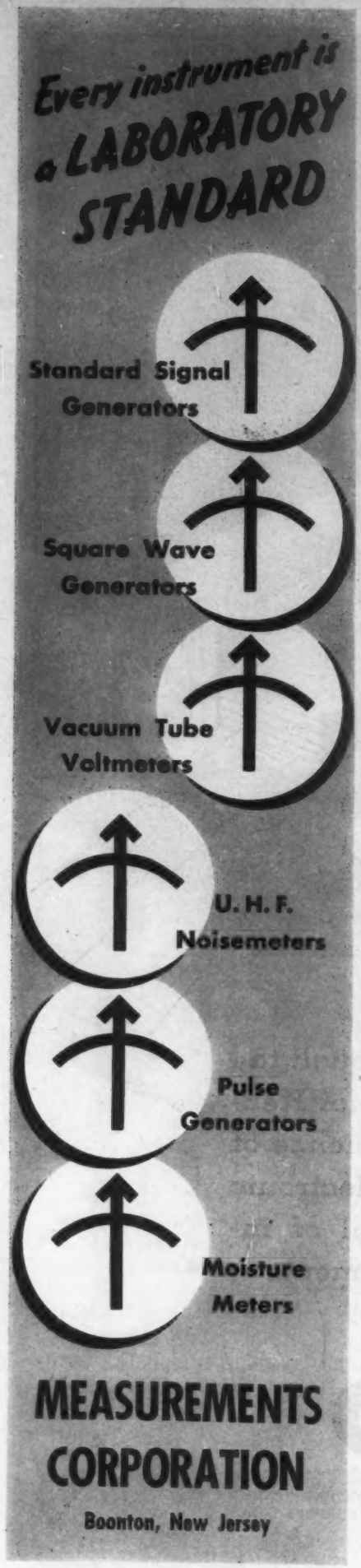

ers, and storage batteries for power.

Some of the novel features of the truck are battery compartments that are accessible from both the inside and the outside of the truck, a built-in dark chamber with light-proof sleeves for loading and unloading film, and a four-inch thick layer of insulation between the ceiling and the roof to insure comfort for technicians.

The front deck of the coach contains a desk for the mixer panel and a removable stool for the operator which can be placed in a floor socket next to the driver's seat. Short jumper cables from the preamplifiers to the mixing panel pass through a small trap door in the deck, so that it is only necessary to run two cables from the recording unit to the set when on location. One cable supplies power for the camera and the other cable connects the microphone to the preamplifier.

New Control Order for Communications Equipment

PREFERENCE RATING Order P-133 has been revised by the War Production Board to make it the exclusive controlling order for obtaining maintenance, repair and operating supplies for radio communication and radio broadcasting. CMP Regulations 5 and 5A, governing expenditures up to $500 for capital equipment under the MRO rating, no longer apply to these businesses.

The amended order continues to give the AA-1 preference rating and use of the allotment symbol "MRO" to persons engaged in the radio communications business, and AA-2 rating and the "MRO" symbol to persons in the radio broadcasting business for obtaining maintenance, repair and operating supplies.

For obtaining these supplies, the rating of AA-5 without the "MRO" symbol is specifically assigned for the businesses of sound recording for commercial, educational and industrial purposes, and in the operation and maintenance of public address, intercommunication, plant sound and similar electronic systems, including systems for the controlled distribution of musical programs. Order P-133 previously had given an AA-2X rating for maintenance, repair and operating supplies for sound recording for commercial uses.

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DUST OFF your ideas on ELECTRONICS

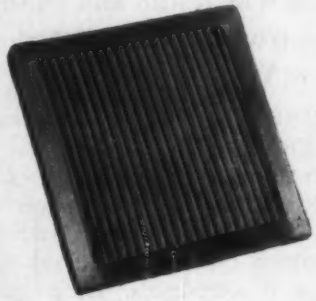
Usually it's not hard to figure out methods of cooling electronic devices. You can punch holes in the housing, install fans or even use water jackets.

Unfortunately, as dust settles on the equipment, less and less heat is radiated, and electrical contacts wear. Under these conditions, the performance of a good electronic idea comes to depend on how often and how well someone cleans it.

The remedy for this nagging problem of the electronic designers is to clean the air that cools their equipment. Air-Maze filters are especially designed for these applications.

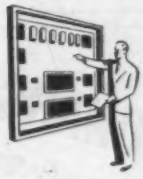
Compact, light and efficient, Air-Maze filters are cleanable and built to last as long as the equipment itself. They are unaffected by temperature or climatic conditions. They can be made in practically any size or shape, and to meet widely varying requirements.

Air-Maze engineers have specialized in air filter design for nearly 20 years. They will gladly help on your problems.



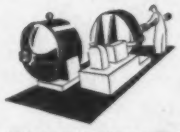
Air-Maze electronic equipment filters combine high dust arresting efficiency with extremely low resistance and compactness. Air-Maze engineers will be glad to make recommendations for particular problems.

A Few Places to Use Air-Maze Electronic Equipment Filters



RADIO TRANSMITTERS

ELECTRONIC WELDING



VOLTAGE REGULATORS

INDUCTION HEATING

Wherever electronic equipment requires ventilation, these Air-Maze filters can be designed and built to solve problems of heat radiation and wear caused by air-borne particles.

AIR-MAZE CORPORATION • *Engineers and Manufacturers* • **CLEVELAND 5, OHIO**

Representatives in Principal Cities • *In Canada:* Williams & Wilson, Ltd., Montreal, Toronto, Quebec, Windsor

AIR-MAZE

SPECIALISTS IN AIR FILTRATION

BUD "AIR WOUND" TRANSMITTER COILS

Although BUD transmitter coils and other precision-made parts are working now for the United States at war, the time is fast approaching when they will be available to you once again.

At that time you will see again how dependability and precision work have made BUD radio equipment among the finest on the market.

BUD RADIO, INC.
CLEVELAND, OHIO

MONARCH
Testing—Measuring Instruments
for the laboratory and production lines, are speeding production in radio and electronic plants all over the country.
Our testing instruments are regularly specified by many manufacturers for shipment with other equipment as government contracts require.
We invite you to consult us on any of your problems, without any obligation.

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point radio communication carriers are exempted from the necessity of obtaining special authorization for the purpose of expanding existing facilities and equipment (but not buildings) to the extent of $1,500 for any one project, and may use the rating and allotment symbol. The exemption was made because these services are engaged in important direct and indirect war activity, the Radio and Radar Division of WPB said.

Other changes in Order P-133 include a clarification of tube inventory restrictions. Use of ratings and allotment symbol to buy or repair a tube is prohibited unless a person has in stock less than one new and one rebuilt tube, or two rebuilt spare tubes per active socket. The previous order did not restrict the number of repaired tubes that could be stocked. However, no important change in the average radio station's stock is likely to result from this restriction.

Another added restriction bars use of the ratings to obtain supplies for the War Emergency Radio Service, the amateur operators' group under the Office of Civilian Defense.

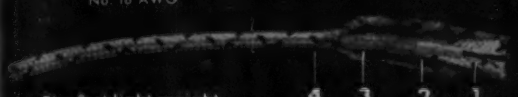
Service repair shops doing maintenance and repair work for persons engaged in radio communication may use the rating and symbol of a customer to do such work, and the restrictions on use of ratings apply as to the customer.

Post-War Radio and Industrial Electronics Discussed at AIEE New York Meeting

AT THE FIRST Fall 1943 meeting of the Institute of Electrical Engineers, Keith Henney, editor of ELECTRONICS, gave a broad survey of the post-war possibilities for radio, communications, and industrial applications of electronics. He pointed out that radio manufacturers should be prepared to produce 18 million receivers in the first 12-month period after the war ends and that inclusion of FM in all receivers selling at $100 or over was inevitable. He stated that the industrial applications of tubes would start off on a new level of sales due to the war, but pointed out that the million-unit, mass-production item for which post-war planners hoped had not yet appeared.

ROCKBESTOS "Permanently Insulated"
SPECIALS for Electronic Applications

ROCKBESTOS FIREWALL Radio Hookup Wire



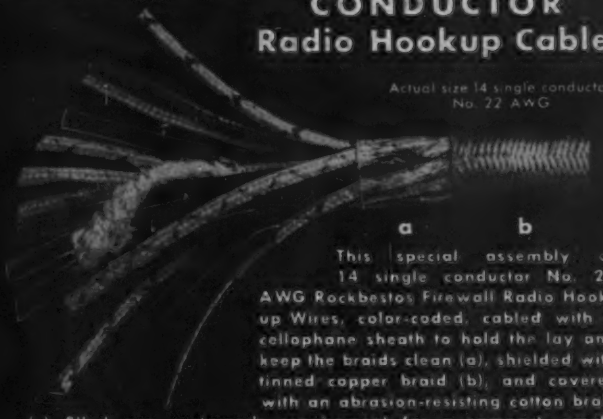
The first light weight, small diameter, flame-resistant hookup wire, designed in 1937, approved by the C.A.A. and widely used since in aircraft radio, ground installations and instruments. Operating temperature range 125° C. to minus 50° C. Sizes No. 22 to 4 AWG, 1000 volt, and 12, 14 and 16 AWG 3000 volt. Constructed as follows:

1. A stranded tinned copper conductor perfectly and permanently centered in helically applied insulation.
2. Then a thin, tough, mechanically strong synthetic tape for uniform high dielectric strength and high moisture resistance.
3. Next, a firewall of resilient felted asbestos, impregnated with heat, flame and moisture-resisting compounds, that acts as a heat-barrier against high ambient temperatures and won't burn even under overloads up to the melting point of copper.
4. Finally, a braid of glass yarn (or cotton or rayon) lacquer-finished to a hard, smooth surface that never becomes gummy or tacky and is resistant to heat, cold, moisture, oil, grease and gasoline.

ROCKBESTOS FIREWALL Hookup Cord

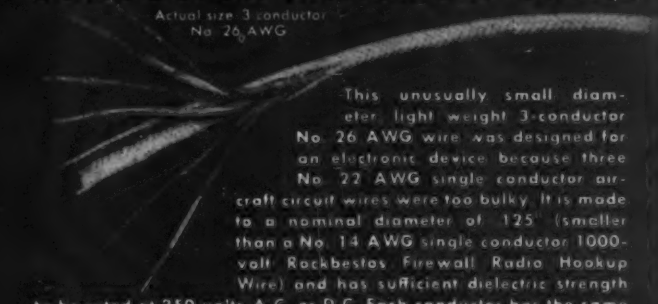
Made in the same sizes and construction as Rockbestos Firewall Radio Hookup wire with either two or three conductors. Braids are plain and color coded. It is also available with a tinned copper shielding braid.

ROCKBESTOS FIREWALL MULTI-CONDUCTOR Radio Hookup Cable



This special assembly of 14 single conductor No. 22 AWG Rockbestos Firewall Radio Hookup Wires, color-coded, cabled with a cellophane sheath to hold the lay and keep the braids clean (a), shielded with tinned copper braid (b), and covered with an abrasion-resisting cotton braid (c) filled one customer's requirement for a compact, small-diameter, light weight, heat, flame and moisture resistant multi-conductor test cable. The individual conductors are of the same construction as Rockbestos Firewall Radio Hookup Wire.

ROCKBESTOS FIREWALL MULTI-CONDUCTOR Instrument Cable



This unusually small diameter, light weight 3-conductor No. 26 AWG wire was designed for an electronic device because three No. 22 AWG single conductor aircraft circuit wires were too bulky. It is made to a nominal diameter of .125" (smaller than a No. 14 AWG single conductor 1000-volt Rockbestos Firewall Radio Hookup Wire) and has sufficient dielectric strength to be rated at 250 volts A.C. or D.C. Each conductor has the same construction as the Firewall Radio Hookup Wire, polarized, then cabled with asbestos fillers to make it round, and covered with a smooth, abrasion-resistant, lacquered cotton braid.

The four wires illustrated show what we mean when we say, "Rockbestos Research solves difficult wiring problems." Originally designed as "specials" to meet customers requirements such as — small diameter, light weight, high dielectric strength, compact multi-conductor construction, resistance to heat, cold, flame, moisture, oil, grease and gasoline,—these wires have now become "standards" in the Rockbestos line of more than 120 wires, cables and cords.

Given the application details, Rockbestos Research will do its best to adapt a "standard" or develop a "special" to fit your particular operating conditions. Just write up the facts and send them to our nearest branch office or:

Rockbestos Products Corporation, 406 Nicoll Street, New Haven 4, Connecticut

ROCKBESTOS RESEARCH

Solves Difficult Wiring Problems

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ST. LOUIS, LOS ANGELES, SAN FRANCISCO, SEATTLE,
PORTLAND, ORE.

★ FOR VICTORY-INVEST IN WAR BONDS ★

2nd
ANNIVERSARY

Two years since the bombing of Pearl Harbor. We can stop now for a moment to survey past events, and see clearly in retrospective things that were once not clearly defined. Let us weigh our losses and our gains . . . and in so doing, let us rededicate ourselves to the only remaining task ahead—to work and produce with fullest determination so that lives may be saved and Victory hastened.

At ABBOTT, we are constantly straining to produce more and better equipment for the Armed Forces. One of these is the ABBOTT Model TR-4 (illustrated) . . . a standard, compact, and efficient ultra-high frequency transmitter and receiver.

Become a Blood Donor . . .
Save a Soldier's Life!

ABBOTT
INSTRUMENT, INC.
8 West 18th St., New York 3, N. Y.

New Officers for IRE

HUBERT M. TURNER, Associate Professor of Electrical Engineering at Yale University, was elected national president of the Institute of Radio Engineers for 1944, and Ralph A. Hackbusch, vice president in charge of radio, Research Enterprises, Ltd., Ontario, Canada, was elected vice president of the Institute.

Hubert M. Turner

Three men were also elected to the Board of Directors: Lawrence C. F. Horle, consulting engineer; Raymond F. Guy, radio facilities engineer for NBC; and William C. White, engineer in the Electronics Laboratory of General Electric Co. at Schenectady.

Television Broadcasters Association Proposed

THE SOCIETY of Television Engineers has suggested the formation of a Television Broadcasters Association, and letters have been sent out by the Society to all companies that are active or prospective television broadcasters. Preliminary indications show that there is a wide interest in such an association. A proposed constitution and by-laws have been prepared by the engineering society, which feels that it can only suggest a possible format for the broadcasting association. A copy of the proposed by-laws can be obtained from the Society of Television Engineers, Box 2830 Terminal Annex, Los Angeles, Calif.

110-VOLTS A.C.
from DIRECT CURRENT

with KATOLIGHT ROTARY KONVERTERS for operating radio and electronic equipment, moving picture projectors, sound apparatus, A.C. appliances, etc.

225 VOLT-
AMPERE CONVERTER

Available in sizes 80 through 2500 volt-amperes, 1800 and 3600 r.p.m., ball bearing designs. Furnished standard 110-volt 60 cycle A.C. from 32,110 or 220-volts direct current. Quiet in operation. Can be furnished with special filtering equipment for sensitive radio work.

PIONEERS IN THE BUILDING OF SMALL ROTARY CONVERTERS

At present Kato's entire production must be directed to furnishing converters on high priority orders. Wire us if you need this kind of equipment for orders.

Also manufacturers of A.C. and D.C. generators ranging from 350 watts through 25 K.W.; power plants; Frequency changers; high frequency generators; and Motor Generator Sets.

KATOLIGHT COMPANY
64 ELM ST. MANKATO, MINN.

THERE'S A DRAKE
SOLDERING IRON
FOR EVERY TYPE OF
ELECTRONIC WORK

From that mighty mite

the Drake No. 400 to the high-speed production "honey"

the Drake No. 600-10 there is a high quality Drake Soldering Iron "just right" for the job.

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Drake Heat Controls and the Drake "Magic Cup" Stand are important soldering aids.

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YOUR RADIO
PARTS JOBBER

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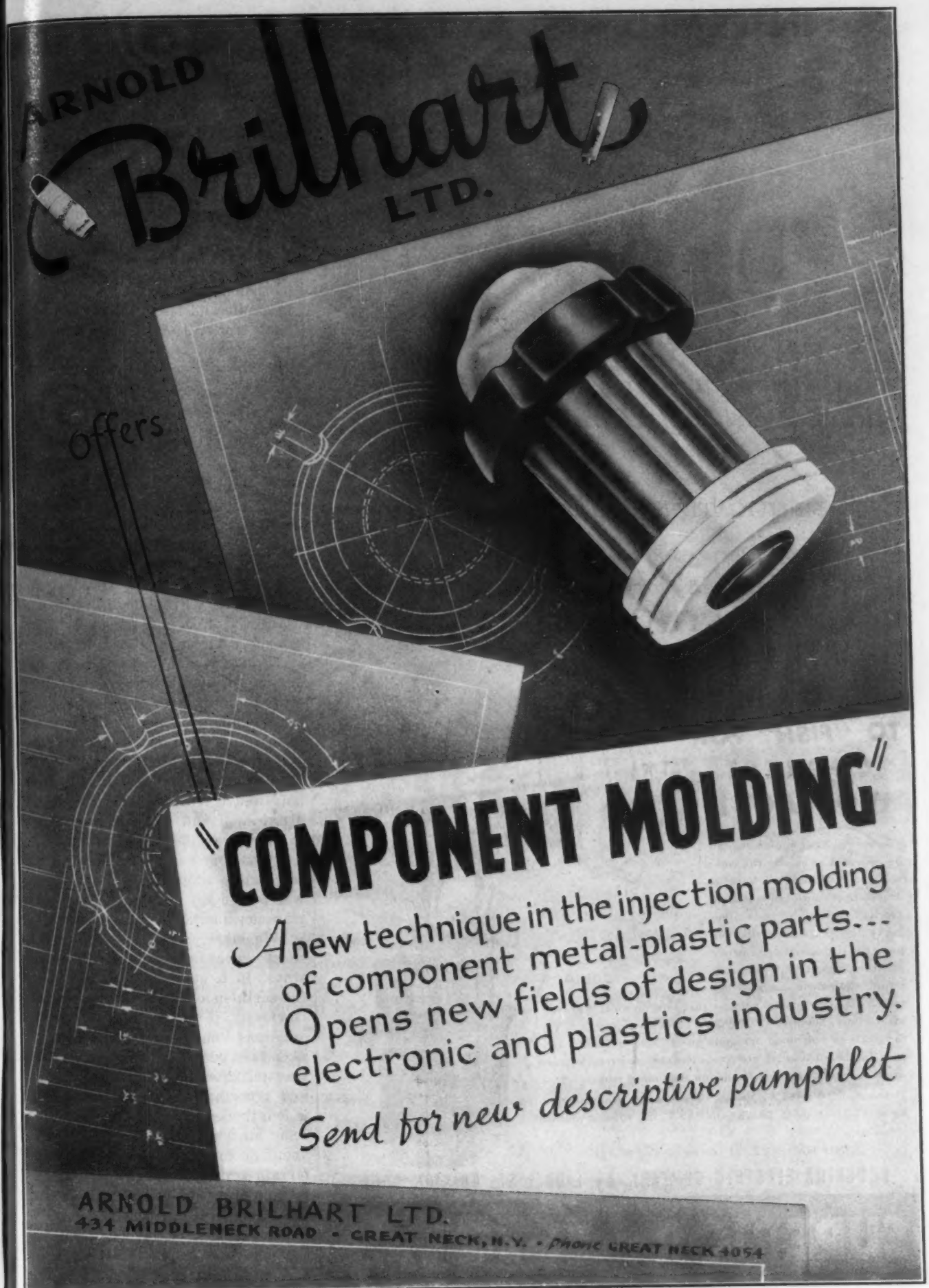
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"COMPONENT MOLDING"
A new technique in the injection molding of component metal-plastic parts... Opens new fields of design in the electronic and plastics industry.
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DO YOU HAVE TO "FISH" FOR CORRECT VOLTAGE?

Your equipment can be operated at exactly the right voltage. POWERSTAT Variable Transformer control of voltage to precise limits can be made either manually or automatically. No longer is it necessary to operate electronic apparatus, heating and testing equipment and other devices at the off nominal voltages that exist on today's heavily loaded lines. Standard POWERSTATS in sizes up to 75 KVA for single or polyphase operation on 115, 230 or 440 volt circuits are designed to replace coarse tap-changing transformers and rheostats having poor regulation and limited range.

Specify POWERSTAT Variable Transformers, manufactured by SUPERIOR ELECTRIC COMPANY, the voltage control specialists.

SEND FOR BULLETINS 149 LE and 163 LE

SUPERIOR ELECTRIC COMPANY, 34 LAUREL ST., BRISTOL, CONN.

SUPERIOR *Electric Company*

Automatic Relays for Television Networks

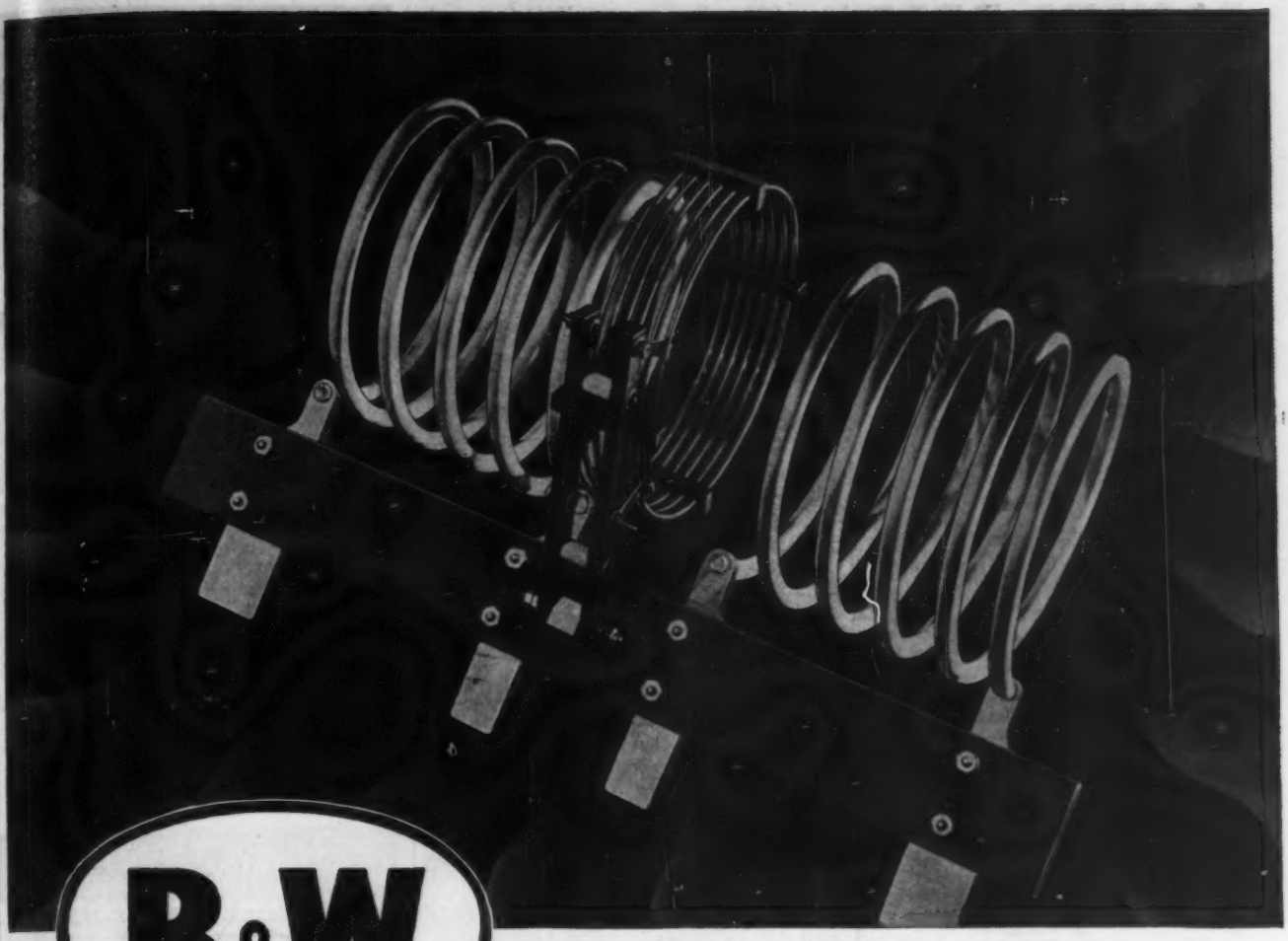
THE LINKING of television stations by the use of unattended relay stations located 20 to 50 miles apart to provide national television networks is anticipated as a post-war development by Ralph R. Beal, research director of RCA Laboratories, in an interview in *Radio Age*, published by RCA.

The relay stations would handle multiple channels and carry several television programs as well as FM, facsimile and telegraph signals. The relay transmitters would operate on microwaves and employ beams so that the power would not be scattered as in broadcasting and also to permit relatively small amounts of power to operate the transmitters.

"It is to be expected," said Mr. Beal, "that television stations will first go on the air in such broadcasting centers as New York, Chicago, and Los Angeles. But there is every indication that alert broadcasters will keep pace with them in such localities as Boston, Philadelphia, Washington, Pittsburgh, Cleveland, Detroit, St. Louis, Kansas City, Omaha, Denver, and San Francisco.

"But television will not be limited to the larger cities. The radio map will be dotted with stations in other cities which, by the use of radio relays, will become outlets for the television network. Before many years pass after the war, these will probably weave from the east across the Mississippi and the mid-west plains to meet a Pacific Coast link striking eastward across the Rockies. A relay station atop Pike's Peak might well be the key station to complete a transcontinental television chain.

"We know, of course, that ultra-short waves and centimeter waves travel in a straight line and leave the earth on a tangent at the horizon. Obviously, if we use high towers or antennas on lofty buildings or mountain peaks, we capture and retransmit the waves at higher levels, and therefore their effective range is lengthened. With the use of radio relay stations, the average range is about 30 miles, depending upon the terrain and various other factors. It is interesting to recall that an airplane over Washington, D. C., carrying a television receiver intercepted the pictures from the NBC aerial on the dome of the Empire State Build-



B&W

"AIR INDUCTOR"

COILS for ELECTRONIC HEATING

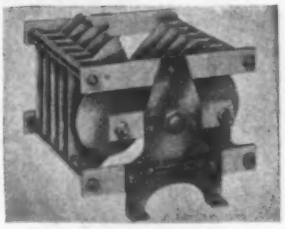
DOZENS OF STANDARD TYPES — OR SPECIALS

Need coils for Electronic heating equipment?

Dozens of standard B &W heavy duty coils have long since proved their effectiveness for such applications—but if the standard line cannot match your specifications, then B & W engineers are well equipped to produce whatever special units may be indicated.

Standard coils are available for Electronic heating requirements up to 1 Kw. Of famous B & W "Air-Wound" design, these are exceptionally sturdy, light in weight, adaptable to numerous mounting arrangements, and have low dielectric loss. Moreover, they are wound to uniform pitch, afford greater design adaptability, and lend themselves readily to mechanical and electrical revisions in circuits that must be adjusted, or which are still in an experimental stage.

Bring your Coil Problems to Coil Specialists!



VARIABLE CONDENSERS

One of the few high-powered types on the market, B & W Type CX Variable Condensers are ideally suited for Electronic heating uses. Available to 12,500 volt rating. Write for Data Bulletin.

BARKER & WILLIAMSON 235 FAIRFIELD AVENUE, UPPER DARBY, PA.

AIR-WOUND, CERAMIC, AND PHENOLIC FORM INDUCTOR COILS

EASY TO READ

EASY, error-free reading is one of the many features of the new General Electric line of ELECTRONIC MEASURING INSTRUMENTS, designed in the famous G-E electronics laboratories. This line provides an extensive choice of compact apparatus for service, maintenance and research.

For measuring electronic circuits and component parts, these units include: G-E unimeters, capacitometers, audio oscillators, wide band oscilloscopes, square wave generators, signal generators, power supply units.

G-E testing equipment is now in production primarily for the Armed Forces. But these stable, shock-resistant units may be purchased on a priority if you are engaged in war work. When peace comes, the full line will be available to everybody.... *Electronics Department, General Electric, Schenectady, New York.*

• *We invite your inquiry for G-E electronic measuring equipment made to meet your specific requirements.*

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Schenectady, N. Y.

Please send, without obligation to me, the General Electric Measuring Instrument Catalog, E-1 (loose-leaf), for my information and files.

*Name*_____

*Company*_____

*Address*_____

GENERAL ELECTRIC
177-84
Electronic Measuring Instruments

ing 200 miles away. But for such long-distance reception of the ultra-short waves, the plane had to go up 20,000 feet.

"Of course, you will understand," said Mr. Beal in concluding the interview, "that I have spoken of these technical developments from the standpoint of the engineer. I realize, as do others, that it will take money to establish such a radio relay system as I have described. Indeed, it will take more than money. It will require a sympathetic and helpful attitude on the part of governmental agencies concerned with licensing and regulation and the daring spirit of the American industrial pioneers who have led the way in so many new developments."

WERS Equipment Transfers

LIMITATION ORDER L-265 has been amended by WPB in order to permit radio amateur operators under direction of the War Emergency Radio Service of the OCD to make or transfer radio sets and electronic equipment for civilian defense emergencies.

The amendment provides that restrictions of the order shall not apply "to gratuitous transfers of electronic equipment to or for the account of the WERS by any person; and to the manufacture or transfer of electronic equipment for the account of the WERS by any individual who is not a commercial producer or supplier of electronic equipment."

Regional Offices of WPB Radio and Radar Division

THE FIELD SERVICE representatives of the Radio and Radar Division of the War Production Board are the Division's direct contact with electronics equipment manufacturers who, in the coming year, must produce $4,500,000,000 worth of material, one-third more than in 1943. The field men render required services to manufacturers relating to supplies of materials, machines, services, and manpower, and assist in filling out necessary forms. They are in touch with 200 end product manufacturers, about 1,000 makers of electronic components and 6,000 suppliers of parts.

To help expedite contacting the field representatives, a list of the

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REFLEX SPEAKERS are now the ACCEPTED STANDARD for all WAR USE

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EVERY REFLEX in the UNIVERSITY LINE is the result of YEARS of RESEARCH

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EVERY REFLEX in the UNIVERSITY LINE has a vital part to play in the WAR PROGRAM

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NUMBERING and LETTERING PRESS

MODEL 40

Quickly stamps serial numbers and other details on name plates, names and numbers on tags, etc. Can also be furnished for HOT stamping. Write for catalog.

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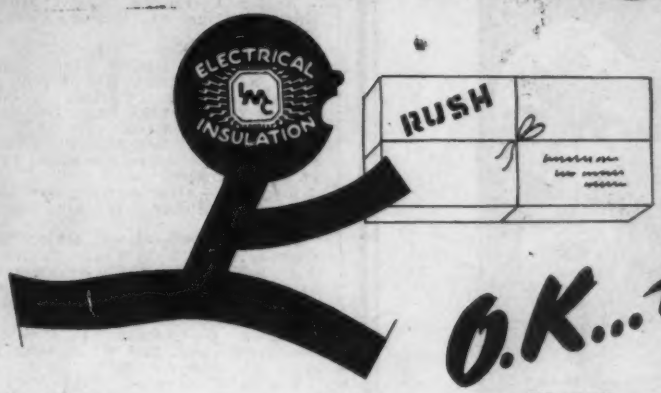
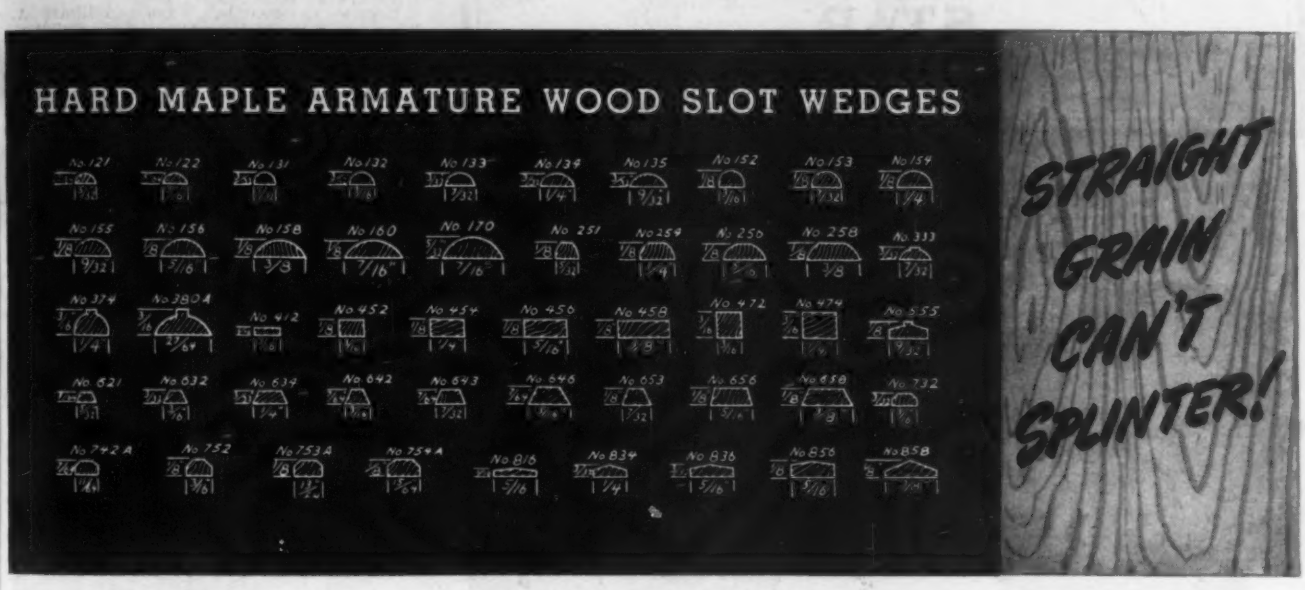
NEED Wood Wedges IN A HURRY?



O.K... Here they are!

• Tremendous production in our own factory of one item . . . Wood Slot Wedges . . . makes it possible for us to offer quick delivery in these days when promises of several weeks are considered good. In addition to quick delivery here are some of the desirable features you will find in our Wood Slot Wedges. (1) Made of straight grained hard maple veneer. (2) Furnished to accurate dimensions to fit every size of standard slot. (3) Tumbled in paraffin to remove splinters and provide a light wax coating. (4) Made to close tolerance. (5) Will not sliver, splinter, or fracture. (6) Lower in price than hard fibre. (7) Large assortment of shapes in standard 30" length; also cut to specified lengths for production work. Specify and order IMC Wood Slot Wedges . . . and get the best!



OTHER IMC PRODUCTS

• Macallen Mica Products—Vartex Varnished Cloth and Tapes—Varslot Combination Slot Insulation—Varnished Silk and Paper—Fiberglas Electrical Insulation—Manning Insulating Papers and Press Boards—Pedigree Varnishes—Dieflex Varnished Tubings and Saturated Sleevings of Cotton and Fiberglas—National Hard Fibre and Fishpaper—Phenolite Bakelite—Adhesive Tapes—Asbestos Woven Tapes and Sleevings—Cotton Tapes, Webbings, and Sleevings.

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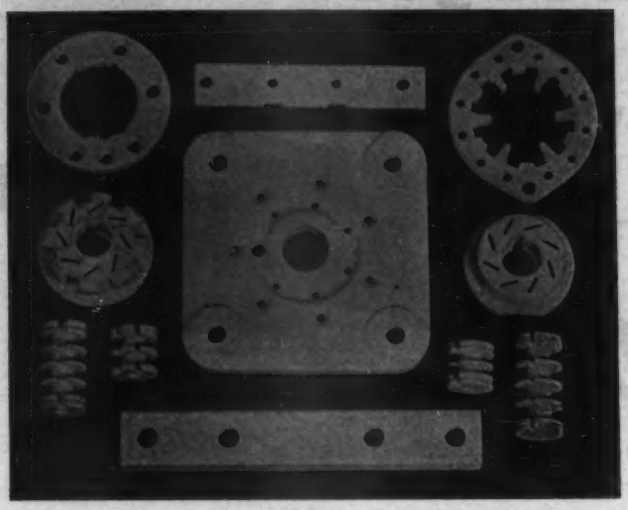
STAR STEATITE



For many years this company has produced a heat resisting ceramic similar to STEATITE under the trade name of LAVOLAIN. The experience and skill thus acquired enabled us to immediately meet the government specifications for

GRADE "G" CERAMICS

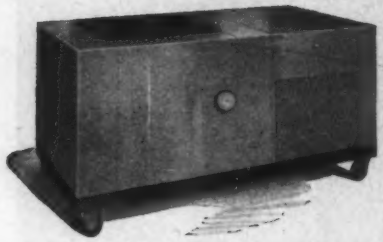
which is available here for those concerns in need of it and having proper priority.

Write for further information

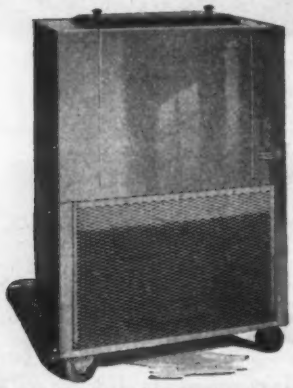
The STAR PORCELAIN COMPANY

Electronics Dept. TRENTON, N. J.

"One - Two - Three - Four - Testing!"



5.4 Cu. Ft. 32" x 34⅞" x 63½"



2.0 Cu. Ft. 48" x 24⅛" x 34⅛"

The chant of the Army or Navy radio operator preparing for action, is definitely allied with Kold-Hold thoroughness and accuracy in developing testing equipment for radio and airplane parts.

Kold-Hold Sub-Zero units provide accurate temperature control conveniently located for the operator at one spot.

The applications of Sub-Zero machines include the testing of airplane instruments, radio receivers and transmitters, conductor wire, crystals, insulators, plastics, glass, lubricating oils, paints, chemicals and others too numerous to list. What are your requirements?

New York Chicago Philadelphia Los Angeles

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446 N. Grand Avenue LANSING, MICHIGAN

regional office locations, the names of the chiefs, and the telephone numbers is appended.

Region 1—Boston, Mass.: Michael Scott, chief, 17 Court St., Boston, Mass., Lafayette 7500.

Region 2—New York, N. Y.: Frank S. Misterly, chief, Empire State Building, New York, N. Y., Murray Hill 3-6800. Branches, Globe Indemnity Building, Newark, N. J., Market 2-0700; 1138 Rand Building, Buffalo, N. Y., Madison 3-160.

Region 3—Philadelphia, Pa.: David Miller, chief, 1617 Pennsylvania Blvd., Philadelphia, Pa., Locust 3400.

Region 4—Atlanta, Ga.: Guy Mankin, 116 Candler Building, Atlanta, Ga., Walnut 4121.

Region 5—Cleveland, Ohio: Howard J. Shartle, chief, 1318 Union Commerce Building, Cleveland, Ohio, Cherry 7900. Branches, 34 E. Fourth St., Cincinnati, Ohio, Parkway 0100; First National Bank Building, Pittsburgh, Pa., Grant 5370.

Region 6—Chicago, Ill.: Raymond H. Woodford, chief, 226 W. Jackson Blvd., Chicago, Ill., Andover 3600.

Region 7—Kansas City, Mo.: Fred H. Larrabee, Mutual Interstate Building, Kansas City, Mo., Harrison 6464.

Region 8—Dallas, Texas:—1221 Mercantile Bank Building, Dallas, Texas, Riverside 5711.

Region 9—Denver, Col.: George Joslyn, Continental Oil Building, Denver, Col., Tabor 1317.

Region 10—San Francisco, Calif.: Harold S. Ayers, 1355 Market St., San Francisco, Calif., Klondike 2-2300. Branch, 1031 South Broadway, Los Angeles 15, Calif., Prospect 4971.

Region 11—Detroit, Mich.: John G. Carroll, 7310 Woodward Ave., Detroit, Mich., Trinity 2-4900.

Region 12—Minneapolis, Minn.: H. M. Richardson, 334 Midland Bank Building, Minneapolis, Minn., Main 3244.

Region 13—Seattle, Wash.: William A. Biesman, White-Henry-Steuart Building, Seattle, Wash., Elliott 0200.

Step Up Electronic Production

AN INCREASE of about one-third over the amount produced in 1943 is required in the production program for 1944 of electronic material needed by the nation. To help meet these increasing requirements for electronic test equipment, a plan for wider subcontracting of orders for critical test equipment, test instruments and components parts has been initiated by the Radio and Radar Division of the WPB.

Since the expansion of facilities is impractical, due to lack of time, construction materials and new personnel, the Division plans to place this extra demand on the industry in places where facilities and competent personnel already exist. Regional offices of WPB have been requested to furnish detailed reports on manufacturers and facilities available for prime or subcontracts for producing test equipment, test instruments and components. At the same time, each manufacturer of electronic test equipment has been asked to indicate which firms would be most capable of adapting themselves to produce, under subcontract, items for the manufacturer's schedule.

What's in a Bale of Cotton?

Who knows? No package of comparable size and modesty is so rightly filled with treasures.

So far, we have found gas masks and boats, signs that warn of danger and direct our pursuing armies along the route of the fleeing foe.

We have found working drawings of amazing clarity and maps that survive duty in the field. We have found identifying tags that stay with parts despite long routes and much handling.

We have found combinations for developments with plastics; book cloths that defy climatic deterioration; and linings for shoes that keep our armies moving on the best marching feet in the world.

These things, and many more, we already have found in a bale of cotton. But the search goes on because *HOLLISTON MILLS* have dedicated their experience and resources first, to discovering more that processed cotton cloths can contribute to the war effort and, second, to the advancement of industry.

CURRENT HOLLISTON PRODUCTION includes COATED AND IMPREGNATED FABRICS, mildew proof . . . fire, weather and water resistant . . . gas impermeable, etc. INSULATING CLOTH BASE . . . SEPARATOR CLOTHS rubber, starch-filled, glazed. TRACING AND BLUE PRINT CLOTHS white and blue, ink or pencil. MAP CLOTH, PHOTO CLOTH, self-adhesive. REINFORCING FABRICS. SIGN, LABEL AND TAG CLOTHS, waterproof to take any ink, meet any inking problem. BOOK-BINDING CLOTHS. SHADE CLOTH, impregnated waterproof, opaque, translucent or light proof.

IN DEVELOPMENT: Mildew-proofing and asphalt-impregnating processes; fire and weather-resistant treatments; synthetic resin fillings and coatings applicable from nettings to duck.

In general, HOLLISTON can convert any print cloth, sheeting, twill and duck in widths from 30" to 80" and can dye, impregnate, coat and fill in any color to specified stiffness or pliability, hand, bond, weight addition and tensile strength, including Elmendorf tear strength, for any trade, commercial or industrial use. We have both the wish and the capacity to cooperate on production problems.

We urge you to consider CLOTH; and invite you to consult with us concerning possibilities and developments for your specific requirements.

THE HOLLISTON MILLS, INC.

CONVERTING CLOTHS TO GREATER USE FIELDS

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Sales Agents in Principal Cities

METAL SHIELDED Wire

VITAL to all communications, Precision Metal Shielded Wire insures protection under the most trying circumstances. One or more insulated conductors can be supplied shielded with Seamless Copper, Brass, Nickel or Aluminum Tubing. Cut to exact size, stripped and formed, ready for instant application, or furnished in random lengths.

Standard stock supplied with Packard or G E Deltabeston Cable to ANJC48 specifications. Also supplied using wire to customer's requirements.

Ready soon — a new catalog. Send your request in at once. Only a limited supply available.

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SALES DEPARTMENT:
215-05 27th AVENUE, BAYSIDE L. I., N. Y.

Anti-Nazi Communications

RECENTLY THE TELEPHONE rang in the office of the Hicksville, L. I. transmitter station of Press Wireless, Inc.

"WPK", the voice asked. "We just picked up a call for you. A station giving identification as YTG wants you to come in on the even hour. They seem very anxious to get you."

Contact was made with YTG who gave the station's location in the "woods and mountains of Yugoslavia." Would WPK handle important government and press messages for them, the station wanted to know. The releases would come from the Democratic News Agency, established for the aid of the fighting forces of Gen. Draja Mihailovich, YTG explained. Shortly thereafter, the first dispatches were transmitted.

Interruptions indicate that YTG is in a "hot spot" near the fighting. After being off the air for two days, YTG apologized when it came on again, explaining that a big battle had been going on nearby. In another instance, YTG left the air in the middle of a sentence. Returning after a few hours, the operator curtly announced, "The Nazis were after us."

How the station was established, how it is equipped and other details about it, Press Wireless and the world would like to know, but no one, probably, will have the full story until after the war.

Radio Business News

WORNER ELECTRONIC DEVICES, new name of the Worner Products Corp. after reorganization, manufactures electronic equipment at 848 North Noble St., Chicago 22, Ill.

SUN RADIO CO. has become Sun Radio & Electronics Co.

SYLVANIA ELECTRIC PRODUCTS, INC. has received the approval of the New York City Board of Estimate for the construction of a two-million dollar industrial research laboratory and home office to be located in Queens County. The proposed location is in a residential area of the city but a change in the zoning regulations was approved some time ago by the Board of Estimate and the City Planning Commission to make the project possible.

Lavite STEATITE CERAMIC

CHARACTERISTICS

Specific gravity of only 2.5 to 2.6
Water absorption S. 1.5-0.001 per cent. Per cent power factor.
S. 1.5 to 60 cycles was only 0.0165.
Dielectric constant at 60 cycles was 5.9-1000 KC 5.4.

Makers of electrical and radio apparatus destined for war service are finding in LAVITE the precise qualities called for in their specifications . . . high compressive and dielectric strength, low moisture absorption and resistance to rot fumes, acids, and high heat. The exceedingly low loss-factor of LAVITE plus its excellent workability makes it ideal for all high frequency applications.

We will gladly supply samples for testing.

D. M. STEWARD MFG. COMPANY
Main Office & Works: Chattanooga, Tenn.
New York Needham, Mass. Chicago Los Angeles

ARGON HELIUM KRYPTON
NEON XENON MIXTURES

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RARE GASES AND MIXTURES

. . . *Spectroscopically Pure*
. . . *Easily removed from bulb without contamination*

Scientific uses for Linde rare gases include—

1. The study of electrical discharges.
2. Work with rectifying and stroboscopic devices.
3. Metallurgical research.
4. Work with inert atmospheres, where heat conduction must be increased or decreased.

Many standard mixtures are available. Special mixtures for experimental purposes can be supplied upon request.

The word "Linde" is a trade-mark of

THE LINDE AIR PRODUCTS COMPANY
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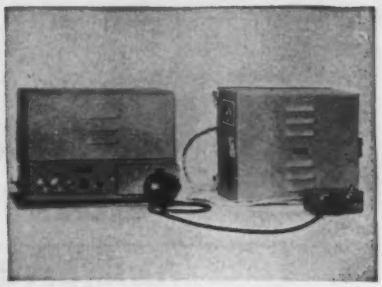
In Canada: Dominion Oxygen Company, Ltd., Toronto

RADIOTELEPHONE EQUIPMENT

FOR *Your* APPLICATION

Complete 22 Watt High Frequency Mobile Installation

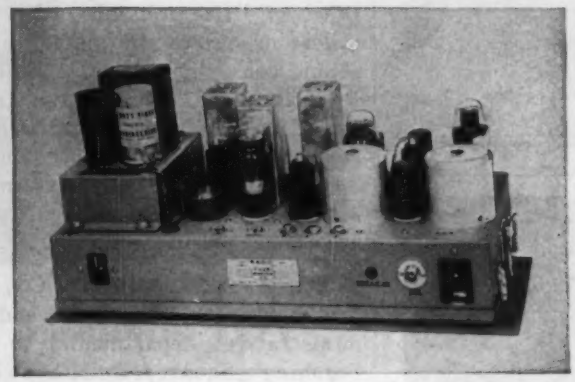
Complete 50 Watt Central Station Installation.



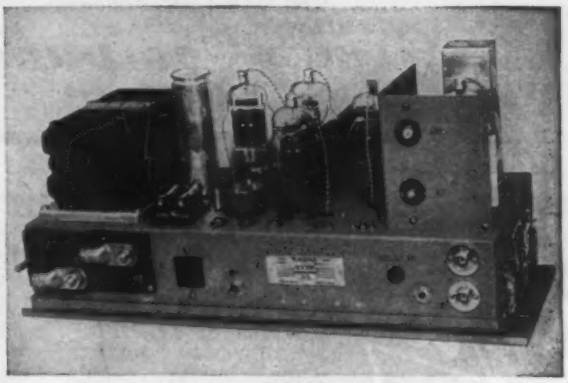
Type 11X Receiver and PTL-10X Transmitter for Mobile Applications.

★ ★ ★ ★ ★ ★

★ ★ ★ ★ ★ ★



Type PRS-9X, 30-40 MC Mobile Receiver with Dust Cover Removed.



Type PTS-22X, 30-40 MC Mobile Transmitter with Dust Cover Removed.

★ ★ ★ ★ ★ ★ ★ ★ ★ ★

PARTIAL LIST OF TYPICAL PRODUCTION MODELS

SERIES 17	10 Watt Multi-Channel Transmitter, Receiver and Power Supply in 8¾" x 15" x 11" Cabinet. 6 and 12 Volt DC and 117 Volt AC Models available.
SERIES 26	20 Watt Multi-Channel Transmitter and Receiver available for operation from 6, 12, 32 and 110 Volts DC or 117 Volts AC.
SERIES 56	50 Watt Multi-Channel Transmitter and Receiver available for operation from 12, 32 and 110 Volts DC or 117 Volts AC.
SERIES 6	Includes Tunable and Multi-Channel Fixed Tuned Receivers for Mobile, Marine or Central Station application.
TYPE 11A	Single Frequency Crystal Controlled Station Receiver for frequency ranges up to 8,000 KC.
TYPE 11X	Crystal Controlled Mobile Receiver, for frequency ranges up to 8,000 KC.
TYPE PTL-10X	Instant Heating 10 Watt Mobile Transmitter, for frequency ranges up to 8,000 KC.
TYPE PTL-22X	Instant Heating 22 Watt Mobile Transmitter for frequency ranges up to 8,000 KC.
TYPE PTS-22X	Instant Heating 22 Watt Mobile Transmitter, range 30-40 MC.
TYPE PR-9X	Crystal Controlled Mobile Receiver, range 30-40 MC.
TYPE PRS-9A	Crystal Controlled Station Receiver, range 30-40 MC.

WRITE FOR QUOTATION ON STANDARD OR SPECIAL EQUIPMENT YOU REQUIRE!

KAAR ENGINEERING CO.

PALO ALTO, CALIFORNIA

Manufacturers of High Grade Mobile and Central Station Radiotelephone Equipment

Electrodes for Crystals

BUTTON TYPE. FLAT OR STEPPED TYPE

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SQUARE, OBLONG AND ROUND

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CLOSEST TOLERANCES

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EXCELLENT FINISH

MINIMUM LAPPING
GREAT SAVINGS IN MAN HOURS AND COSTS

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Gemex Company
UNION, NEW JERSEY

Pyroferric IRON CORES

Pyroferric powdered metal cores have kept apace the vital precision instrument development. They are manufactured to specification:

PERMEABILITY } HIGH
"Q" } as desired
RESISTANCE } LOW

FREQUENCY { HIGH / MEDIUM / LOW

Consult Pyroferric on your Powder Metallurgy requirements

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175 VARICK STREET NEW YORK, 14, N. Y.

CRYSTAL RESEARCH LABORATORIES has appointed six employes to executive positions. Henry F. Jochim has become vice-president; Richard K. Blackburn, chief of radio engineering and research; Ernest B. Lewis, general production manager and crystallographer; Norman Chalfin, radio and x-ray engineer; Richard B. Wolcott, chief mechanical engineer; and Frederick T. Wells, production manager.

LEWYT CORP. has inaugurated a "Girl Friday" training course in which girl workers are taught management and foremanship to qualify them to take over detail work for foreman and department heads. The term "Girl Friday" was chosen to inject a note of novelty into the program and to show that each girl is the right-hand woman of a group leader.

CEILING PRICES on assembled radios and phonographs must be figured by a new method put into effect by the Office of Price Administration. Retailers or others who assemble sets should get a copy of Maximum Price Regulation No. 430 from their nearest OPA office, and immediately fix ceiling prices in accordance, since it is illegal to sell or deliver assembled sets until they have been priced in accordance with the regulation.

NORTH AMERICAN PHILIPS CO., INC. has moved its commercial and administrative departments to the Pershing Square Building, Park Avenue at 42nd St., New York from Dobbs Ferry, N. Y. The Industrial Electronics Equipment Division also moved to the Pershing Square Building.

FINANCING OF RESEARCH by the Government was urged by vice-president Henry A. Wallace when he appeared before the Senate Military Affairs Committee recently. He appeared to support Senator Kilgore's bill which would establish an office of scientific and technical mobilization for post-war activity.

—◇—

COTTON WRAPPINGS on headset cords used in military communications are now burned off by a hot wire instead of clipping them off with scissors, at the Bridgeport, Conn. G-E plant. This time-saving idea brought a $900 award to Mrs. Anna Turnbull, G-E employee for 37 years.

CHOICE OF TYPES

- **Molded-in-bakelite capacitors in widest choice of designs, sizes, mountings. In brown bakelite and also in XM (yellow) low-loss bakelite.**
- **Silvered mica capacitors for highly critical applications. Average temperature coefficient of only .002% per degree C. Excellent retrace characteristics. Practically no capacity drift with time. Exceptionally high Q—3000 to 5000 in higher capacities.**
- **Type K compensating capacitors. Temperature coefficient such that product of "L" and "C" will be independent of temperature changes.**
- **Stack-mounting units, bakelite—case units, metal-case units, etc.**

● Be it tiny "postage-stamp" mica capacitor or large stack-mounting unit—regardless, it's a *precision* product when it bears the Aerovox name.

Only the finest ruby mica is used. Each piece is *individually gauged and inspected.* Uniform thickness means meeting still closer capacitance tolerances. Also, sections are of exceptionally uniform capacitance, vitally essential for those high-voltage series-stack capacitors. Meanwhile, the selection of perfect mica sheets accounts for that extra-generous safety factor so characteristic of ALL Aerovox capacitors.

Our new Transmitting Capacitor Catalog lists the outstanding choice of types. ● Write on your business stationery for your registered copy.

AEROVOX *Capacitors*

INDIVIDUALLY TESTED

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for the
PHILCO
ENGINEERING
STAFF

- **RADIO—ELECTRONICS—ELECTRICAL ENGINEERS**
  Men with degrees in electrical engineering or comparable experience in radio and television.
- **MECHANICAL ENGINEERS**
  Men with college degrees or comparable experience in the engineering aspects of electrical appliances, and in designing small machinery.
- **DESIGN ENGINEERS — DRAFTSMEN**
  Men with experience in mechanical designing, especially of small metal parts and of the automatic machinery to mass-produce them.
- **PRODUCTION ENGINEERS**
  Including electrical and mechanical engineers familiar with any phase of radio, radio-phonograph and television production.
- **PHYSICISTS**
  Must have science degree in physics. Some practical experience in radio is desirable.

WE expect the men who qualify for these positions to become permanent members of our staff and take an important part in our post-war program.

To maintain the Philco tradition of progressive research and development, is first and foremost in our minds. We provide the finest of technical equipment. But often, even more helpful is the inspiration and personal assistance of working with men who have done so much for the advancement of Radio, Television, Refrigeration and Air-Conditioning.

WRITE US TODAY

Qualified men not now engaged in work requiring their full talents, are invited to write us in detail as to their experience, education, family and draft status, and salary. Letters will be treated in strict confidence.

Employment subject to local W.M.C. rules.

WRITE TO MR. GEORGE DALE

PHILCO
CORPORATION
Philadelphia 34, Penna.

Personnel

Helen Koppe, assistant engineer in the Emerson Laboratory, was interviewed recently on the "Woman-power" program, broadcast over WNEW, New York.

Robert D. Kirkland, engineer with Mackay Radio & Tel. Co., died recently after several months illness.

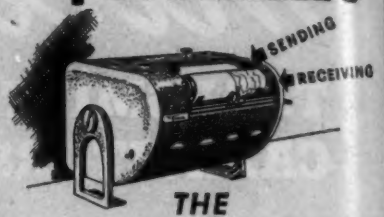
Major Carl B. Kleinau, in civilian life a supervising engineer with the Southern Calif. Tel. Co., has been designated acting chief of the Aircraft Radio Branch of the Engineering and Technical Service in the Office of the Chief Signal Officer. He replaced Col. James K. De Armond who has been assigned to the Army Air Base at Orlando, Fla.

James G. Kellogg has returned as president of Kellogg Switchboard & Supply Co., succeeding Major Maurice K. McGrath who recently resigned and continues as a director in the company.

H. Gregory Shea, formerly chief industrial engineer at the Utah ordnance plant of the Remington Arms Co., has been appointed production manager of Electronic Corporation of America.

John A. Hutcheson has been appointed associate director of the Westinghouse Research Laboratories where he will head micro-wave research. For the past three years he has been manager of engineering at the Baltimore Radio Division of the company

finch facsimile



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(Transmits pictured messages by radio or wire—at electric speed)

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For the present, Finch manufacturing facilities are being devoted to special radio apparatus for . . .

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U. S. NAVY
U. S. ORDNANCE DEPT.
F. C. C.
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U. S. TREASURY DEPT.
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FINCH
TELECOMMUNICATIONS, Inc.
PASSAIC, N. J.

PREMAX

Premax Antennas On Sea and Land

Developed and manufactured by Premax in standard and special designs, these Antennas are proving themselves every day . . . on sea . . . on land.

For the important task of maintaining communications under the most adverse conditions, Premax Antennas are making good. Send for details of standard models.

Premax Products

Division Chisholm-Ryder Co., Inc.
4402 Highland Ave., Niagara Falls, N. Y.

Meets "On the spot" requirements

IN MANY VITAL INDUSTRIES

(Photograph Actual Size)

MORE THAN JUST A RELAY

...Heavy Duty, Light Weight CONTACTOR

Explosion-proof!
Vibration-proof!
Dust-proof!

Sec'ed Chamber—Makes Relay Explosion Proof and Dust Proof; serves as effective arc quench.

Excess Capacity—Rated at 25 amperes; tested satisfactorily at 50 amperes: intermittent duty.

Light and Compact—Standard model above (S47D) weight only 4 7 ounces; overall dimensions as follows: Height, 1 9/16"; Width, 1 21/64"; Length (less base), 1 7/16"; Overall of base, 2 1/16"; Mounting holes, center to center, 1 3/4"

Positive Action—Overtravel spring insures positive contact pressure and instant "break" release.

Tamper Proof—Factory adjusted and sealed; protection against unauthorized re-adjustments.

Reversible Contacts—If worn from excessive use contacts may be reversed in the field, thus providing new surfaces without disturbing adjustment.

Specifications—Normal Coil Rating. 24 volt - 150 m. a. - 3.6 watts. Contact Rating. 25 amps. inductive load at 30 volts

Unit has withstood Army tests, including overload; vibration 55 cycles per second with .06" excursion; acceleration of 10 gravity units; salt spray tests of 240 hours duration.

ET US WORK WITH YOU ON YOUR ONTACTOR APPLICATION PROBLEMS

Electrical
PRODUCTS SUPPLY CO.
Affiliated with Electrical Products Corp.
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NOW IN PRODUCTION:

CD-318-A	JK-48	PL-68	PE-86
CD-307-A	PL-47	"A" Plug	SW-141
CD-874	PL-54	BC-366	JB-47
JK-26	PL-55	BC-347-C	

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CRYSTALS

DX
XTALS

'the heart of a good transmitter'

Complete automatic production plus electronic measuring and testing in temperature ranges from —30° to 130° F. make DX Xtals perfect, modern, tele-communication instruments. Ample production of these "battle-tested" types allow for civilian delivery of many cuts and frequencies — priorities, of course.

DX CRYSTAL CO.
GENERAL OFFICES: 1841 W. CARROLL AVE., CHICAGO, ILL., U.S.A.

DX XTALS
'the heart of a good transmitter'

William S. Paley, president CBS, has been given a leave of absence by the directors of CBS that he can accept an assignment from OWI to help in the radio phase of psychological warfare in the Mediterranean area.

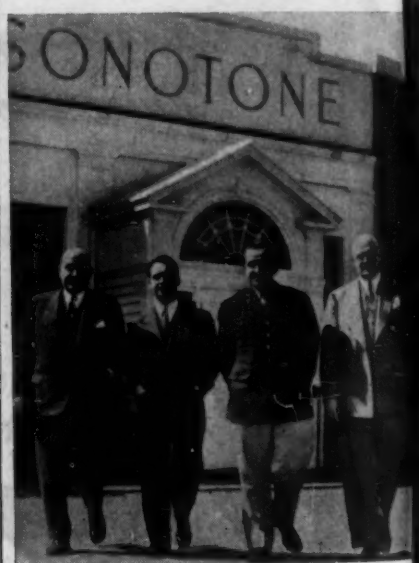
Lt. Col. Paul E. Watson, director of the Army Signal Corps Laboratory at Camp Evans, a sub-post of Fort Monmouth, died from a cerebral hemorrhage at the Fort Monmouth Post Hospital. Army officials considered him an outstanding technician in VHF laboratory work.

I. R. Weir, former section leader of the high power section of the Transmitter Division of General Electric, has been appointed assistant to the designing engineer of the Transmitter Division of the Electronics Department.

R. H. Siemens has been appointed chief engineer of RCA Victor Argentina. He succeeds Paul Bennett who has returned to Camden.

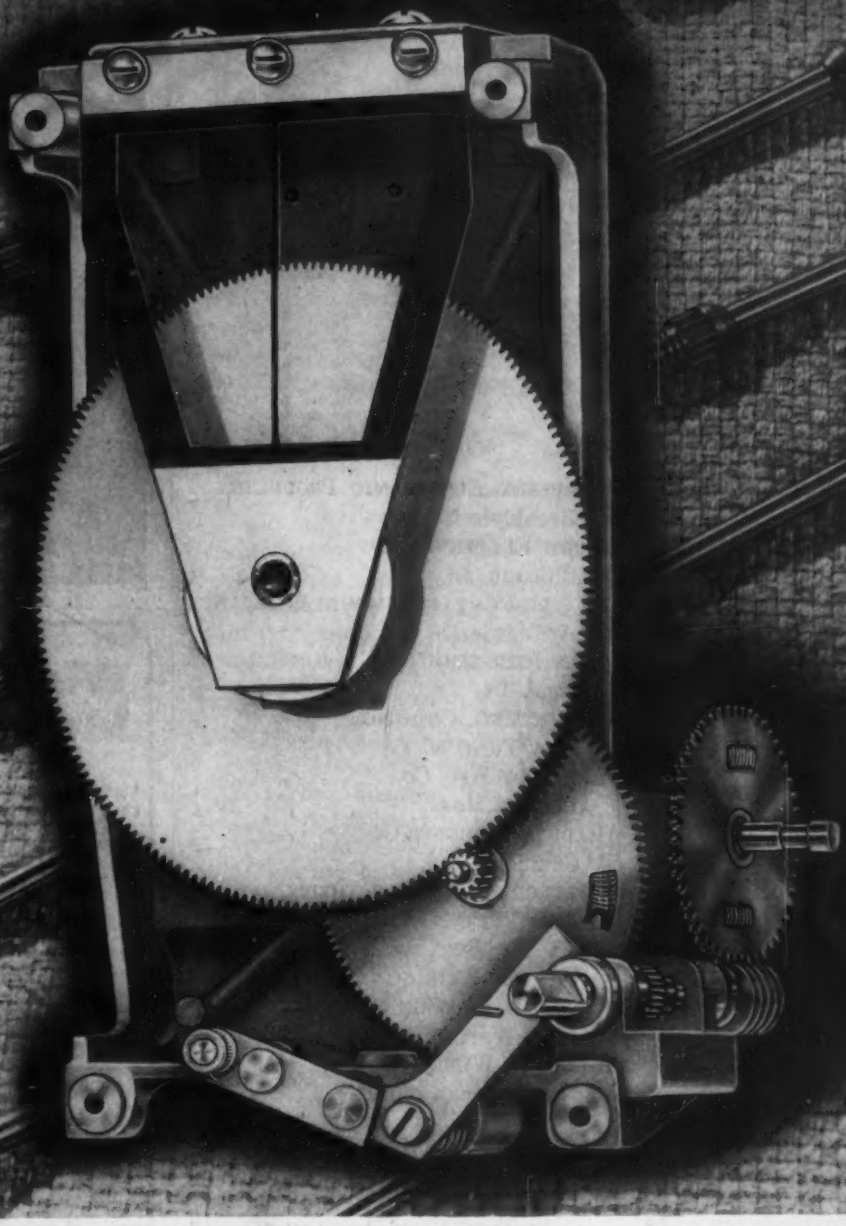
Clarence G. Stoll, president and director of Western Electric, was elected to the board of governors of NEMA at their annual meeting.

Maurice E. Levy, formerly chief of the radio division of Stromberg-Carlson, is now manager of Emerson's special equipment division.



On a recent visit to the Sonotone plant Major S. E. Petrillo, Chief Engineering Officer of the Ground Signal Branch of the Signal Corps, met Louis G. Pacent, consulting engineer; I. I. Schachtel, vice-pres.; and Dean Babbitt, pres., left to right

CRONAME Electronic Controls



PRECISION RADIO AND COMMUNICATION OPERATING MECHANISMS BUILT TO SPECIFICATIONS

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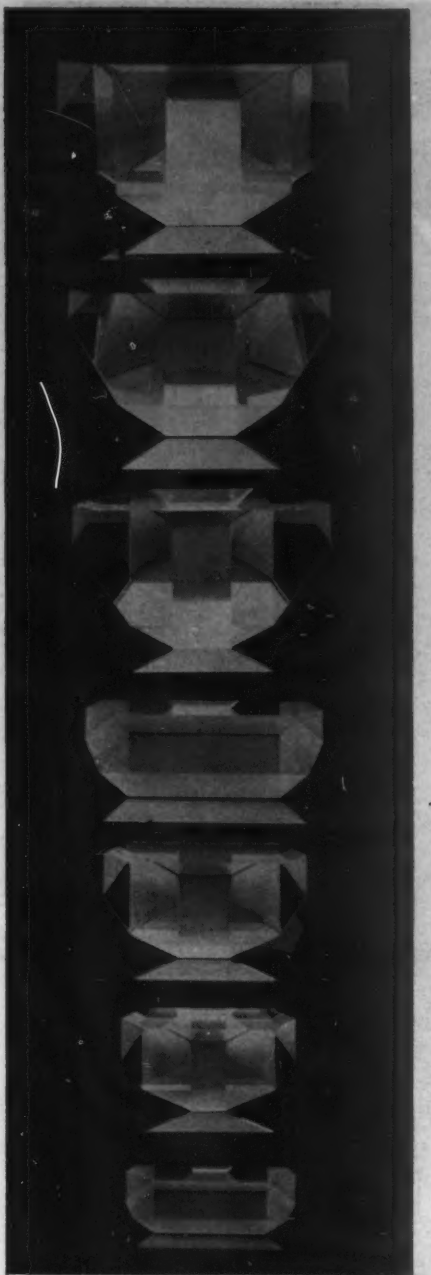
LOS ANGELES SAN FRANCISCO



● The ROOF PRISM is the most accurate part of any military instrument in which it is used. First to develop quantity production of these highly important "war-weapons", The Perkin-Elmer Corporation is gladly making its methods available to others engaged in military production.

THE PERKIN-ELMER CORPORATION

Glenbrook, Conn.

Prof. Pieter Zeeman, one of Holland's greatest scientists, died in Amsterdam, according to the Dutch news agency Aneta. He discovered the "Zeeman effect," produced in spectroscopy by the splitting up of spectral lines in a magnetic field, useful in studying magnetic effects and spots on the sun.

AMPEREX ELECTRONIC PRODUCTS,
Brooklyn, N. Y.
COOK ELECTRIC CO.,
Chicago, Ill.
E. I. DU PONT DE NEMOURS & CO., INC.,
Arlington, N. J.
ERIE RESISTOR CORP.,
Erie, Pa.
ESPEY MFG. CO., INC.,
New York, N. Y.
MCELROY MFG. CO.,
Boston, Mass.
RADIO CONDENSER CO.,
Camden, N. J.
REEVES SOUND LABORATORIES,
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WILLIAM E. WRIGHT & SONS CO.,
West Warren, Mass.
RUDOLPH WURLITZER CO.,
North Tonawanda, N. Y.

A ONE-POUND steel ball dropped from 3 ft. bounces harmlessly off a 1-in. thick piece of Prestite, new porcelain developed by Westinghouse engineer Eugene H. Fischer. His ceramic is moulded in steel dies under high pressure, and can easily be shaped into intricate designs. It is being used for radio tube bases and capacitor insulators as well as for insulating high-voltage equipment.

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WRITE FOR YOUR COPY TODAY
NEW SpeedWay
MOTOR CATALOG
Shows description, gives dimensions and output of small motors from 1/3000 h.p. to 1/3 h.p. plain and back-geared motors for A.C., D.C., or Universal operation—dependable, efficient and economical SpeedWay Motors embodying the "know how" developed through more than 30 years of specialization in small motors — the "know how" that has answered so many war problems, for all branches of the service.
If you use small motors, write for this new catalog today. If you have small motor problems send in your specifications for SpeedWay's recommendations.
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Here's news for men in radio and electronics—

JUST OUT!

Radio Engineers' Handbook

More than 1,000 pages, 6 x 9

profusely illustrated

$6.00

By Frederick E. Terman

Professor of Electrical Engineering and Executive Head, Electrical Engineering Department, Stanford University (absent on leave), Director, Radio Research Laboratory, Harvard University

One of the most complete works of its kind ever published, this outstanding reference work presents a wealth of essential theory and up-to-date standards, practice, and data, especially selected and organized to meet the needs of the engineer dealing with practical radio and electronic problems.

13 big sections, covering

1. Tables, Mathematical Relations, and Units
2. Circuit Elements
3. Circuit Theory
4. Vacuum Tubes and Electronics
5. Vacuum-tube Amplifiers
6. Oscillators
7. Modulation and Demodulation
8. Power-supply Systems
9. Radio Transmitters and Receivers
10. Propagation of Radio Waves
11. Antennas
12. Radio Aids to Navigation
13. Measurements

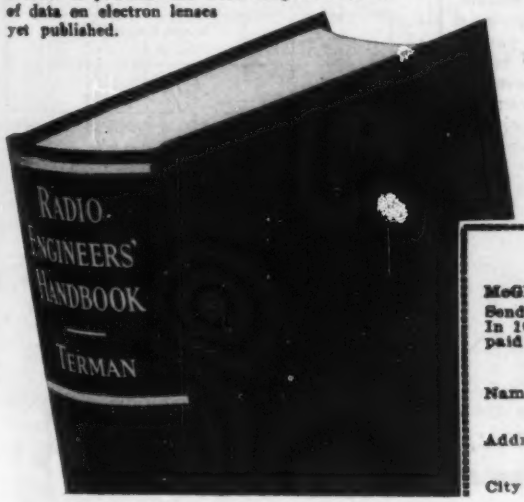
Terman's Handbook concentrates on those topics which the radio man thinks of as constituting radio engineering—presented in concise descriptions, fundamentals, formulas, procedures useful in actual design, tables, diagrams, etc. Consult it for data needed in routine problems of design and practice, or in investigation of special problems or branches of work. Check your methods against best accepted practice. Save time, trouble, and error—get quick, dependable answers to your questions, *when* you need them, from Terman's Radio Engineers' Handbook.

See one of the first copies off press. Just mail the coupon; pay for or return the book after examination. This authoritative and convenient summary of radio engineering knowledge can be of constant and valuable aid to you. Send the coupon today.

Some Features of the Handbook

The formulas and curves on skin effect, inductance, mutual inductance, and capacity represent the most complete collections ever presented in one place. The same is true of the transmission-line equations, the formulas for field patterns and radiation resistance of antennas, the treatment of ground-wave and ultra-high-frequency propagation.

Network theory is covered in a straightforward and comprehensive way that will help widen the understanding of such matters as Foster's reactance theorem, attenuation and phase equalizers, lattice and ladder filters of various types, impedance matching and insertion loss, the relation between attenuation and phase shift, etc. The treatment of electron optics is noteworthy in that it is the first summary of the subject that has appeared in handbook form, and also because it presents the most complete collection of data on electron lenses yet published.



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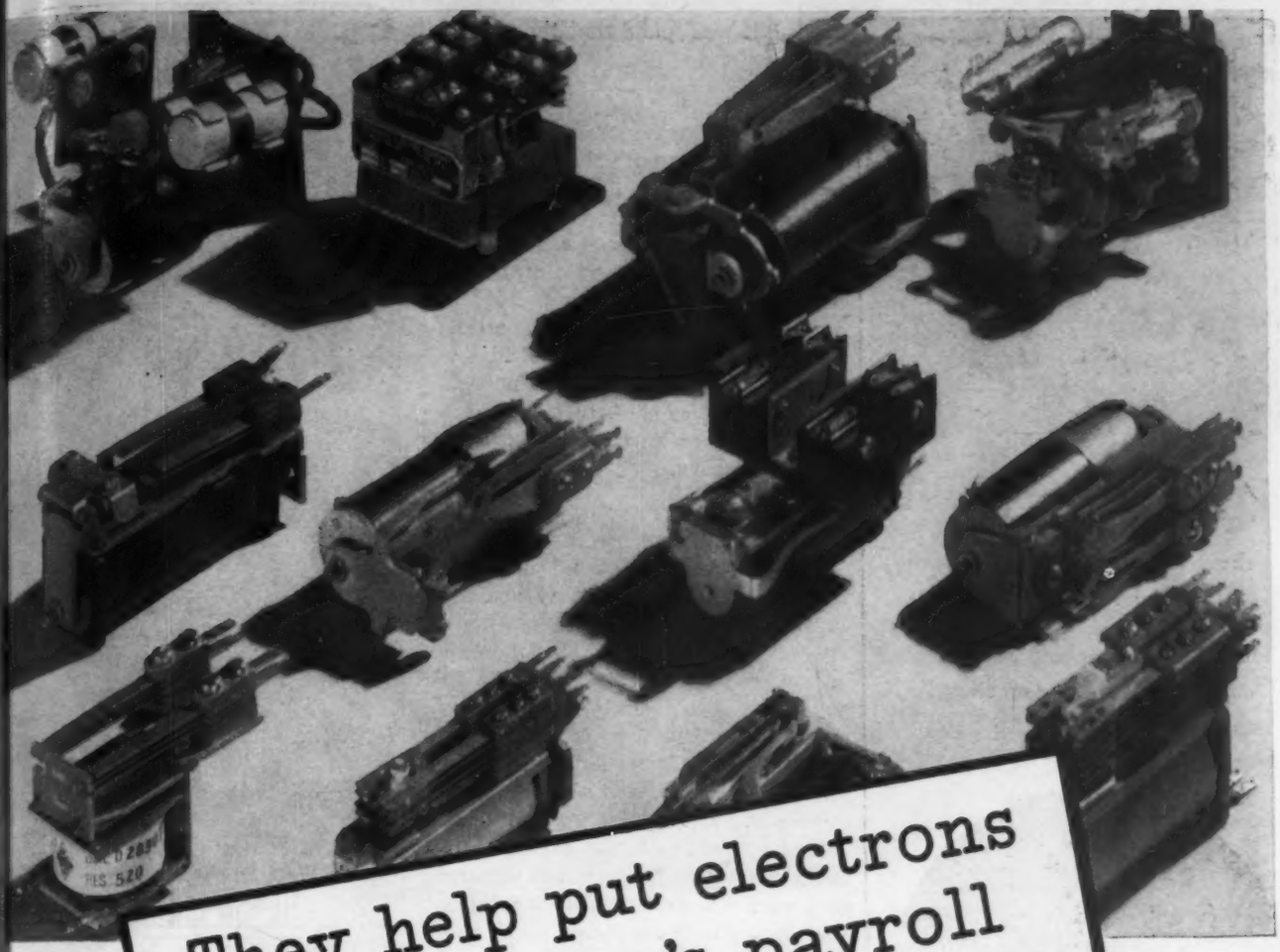

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Broadcast Arrays

(*Continued from page* 123)

circuit is revealed by adding Eq. (25) and Eq. (26):

$$\bar{I}_L + \bar{I}_C = \frac{(M+j)\,\bar{E}}{MR + jR} = \frac{\bar{E}}{R} \quad (28)$$

This equation shows that, as long as Eq. (23) and Eq. (24) are satisfied, the input impedance of the circuit is a pure resistance of value R.

The power flowing into the inductive branch (power into tower No. 1) is

$$P_1 = I_L^2 R \quad (29)$$

while the power into the capacitive branch (power into tower No. 2) is

$$P_2 = I_C^2 R \quad (30)$$

or, dividing Eq. (29) by Eq. (30),

$$I_L/I_C = M = \sqrt{P_1/P_2} \quad (31)$$

But, from Eq. (21),

$$P_1 = 71.7\, I_1^2 \quad (32)$$

and from Eq. (22) and the fact that $I_2 = 0.912\, I_1$,

$$P_2 = 44.0\, I_2^2 = 36.6\, I_1^2 \quad (33)$$

Dividing Eq. (32) by Eq. (33),

$$P_1/P_2 = 1.96 \quad (34)$$

so that Eq. (31) yields $M = 1.4$, and with R equal to the characteristic impedance of the transmission lines (70 ohms), the series capacitive reactance is 98.0 ohms, while the series inductive reactance is 50.0 ohms. When the circuit of Fig. 13 was installed, impedance measurements were made at the common feed point with the results shown in Fig. 15.

When these components were in-

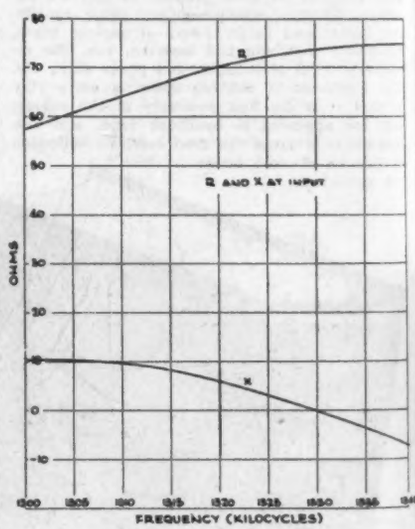
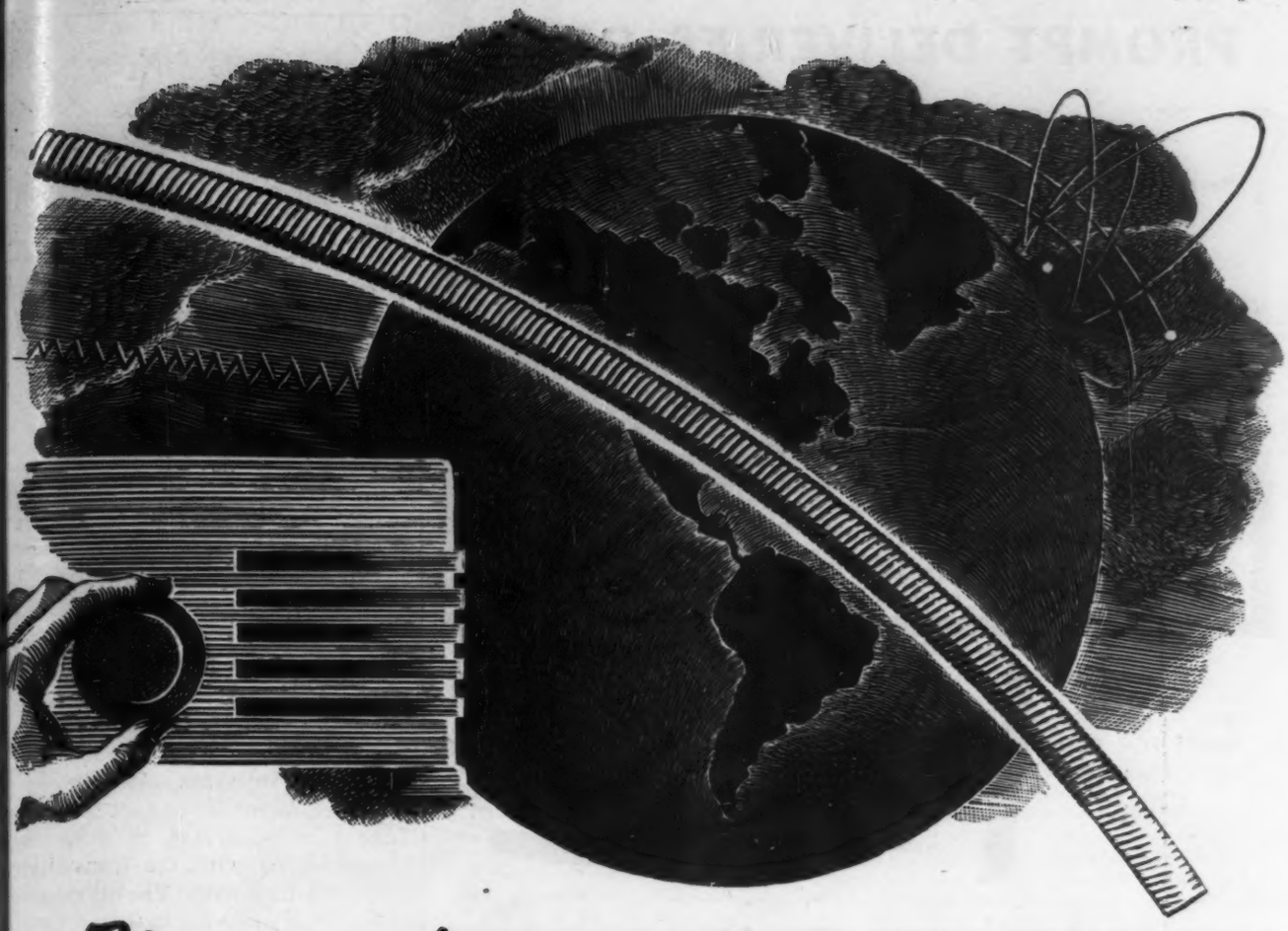


FIG. 15—Results of impedance measurements at the common feed point in Fig. 13 for frequencies on each side of the assigned frequency of 1320 kc



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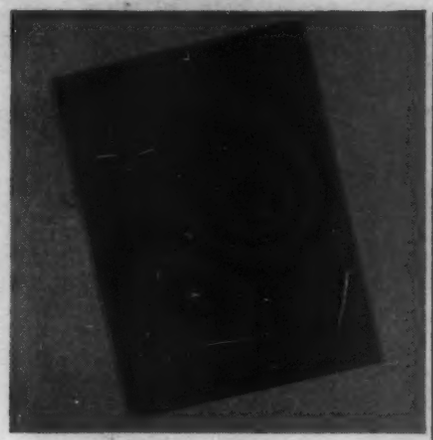

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stalled, it was found that the current relations were

$$\bar{I}_3 = 0.88\,\bar{I}_1 \angle + 160^\circ \qquad (35)$$

While these values were not in exact agreement with those predicted by the two methods described in this paper, it was known from calculation that the desired pattern could be obtained with this experimental relation. Accordingly, it was decided to measure the field intensity pattern before proceeding with fine adjustments. It was found that the pattern obtained was so close to the desired pattern that no further adjustments were necessary.

Measured Field Intensity Pattern

While the mountains and rocky terrain around Salt Lake City are the cause of very high attenuation, there are also present some of the most highly conductive areas to be found anywhere. This highly conductive area lies to the northwest of Salt Lake City, and is caused by the lake itself and the several thousands of square miles of dried-up lake bed, rich in mineral salts. As a result, any particular type of directional pattern soon loses its identity, since the high attenuation to the east and south and the high conductivity to the northwest and west stretch and constrict the pattern all out of its original shape. In fact, the extremes of conductivity and attenuation are such that no directional pattern can remain looking like a directional pattern when measured on a radius of around 100 miles. As a practical result, the benefit derived from the use of a directional array is that the sky wave in the direction of co-channel stations has been reduced, thus permitting the use of higher transmitter power. There is, of course, the added consideration that in certain strategic directions, the high-angle radiation is increased. This helps provide a service in sections where the ground wave dies out rapidly.

Another point noted in proof-of-performance measurements was that measurements made on the east radials at distances up to about one and one-half miles from the towers showed less signal intensity than was indicated by the projection of the curve joining intensity measurements made further away, and conversely that measurements on the west radials showed just the reverse of this effect. These effects are

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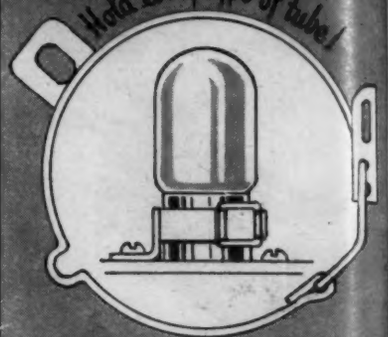

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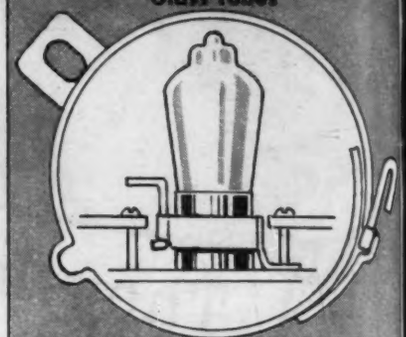

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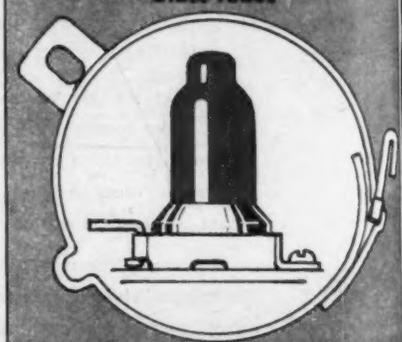

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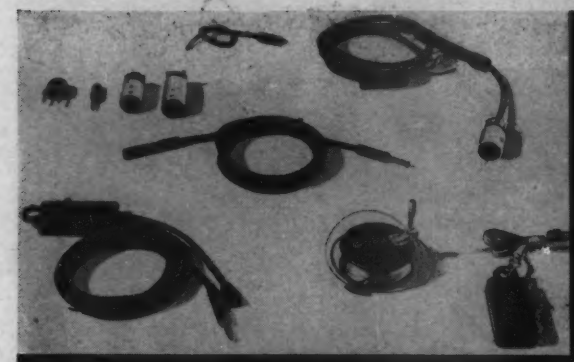

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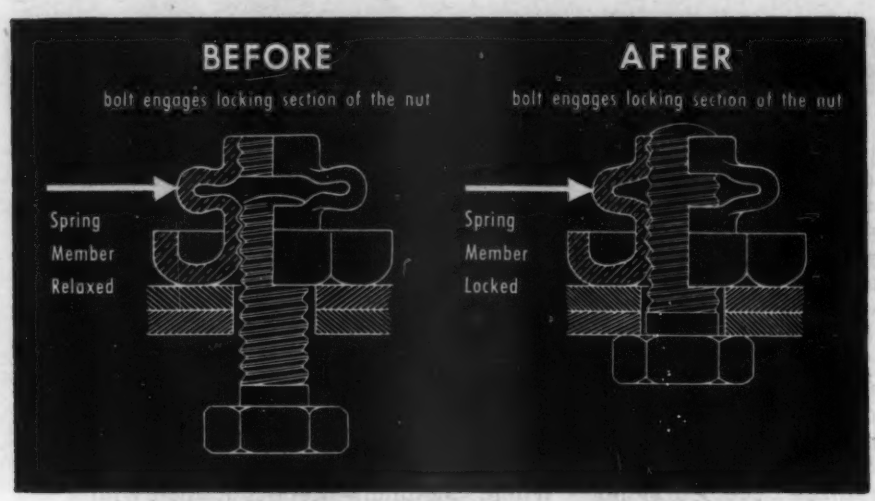

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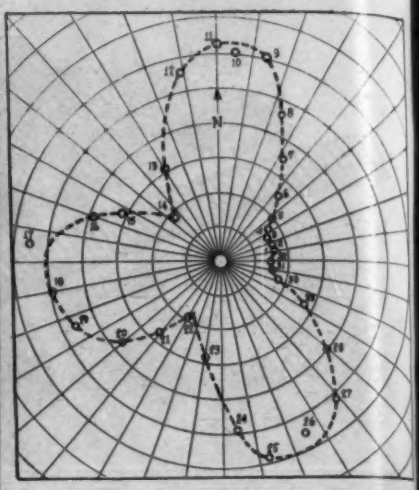

FIG. 16—Final measured polar radiation pattern obtained after antennas of KDYL were adjusted according to the procedures in this article. Compare with the initially desired pattern in Fig. 1

caused by the fact that the towers are spaced sufficiently that at distances of less than one and one-half miles the reciprocal distances from the measuring set to the two towers are unequal. Another contributing factor is the fact that Salt Lake City is located in a saucer-shaped valley with the transmitter near the lowest point. The differences in elevation are such that in a great many parts of the city it is possible to get a direct airline signal from the transmitter. Since the city lies toward the north and east of the transmitter site, where the ground level rises continuously, it is not possible to evaluate the true conductivity in these directions by radial field intensity measurements.

To overcome these effects and to obtain a horizontal field intensity pattern which was a function of the array constants and not of the terrain, it was decided to follow a comparison procedure. The first step was to float tower No. 2 and to feed tower No. 1 with 5 kw of power. Then field intensity measurements were made at 32 selected locations at various angles about the array. Each location was approximately two and one-half miles from the array. It was not necessary to measure the distance. It was only necessary that the point selected be far enough away so that the free space pattern could shape itself. Then the array was fed in the desired manner and the fields again measured at these selected points. At each particular point, the directional field intensity was then divided by the nondirectional field

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intensity to secure a ratio which could be plotted to show the directional pattern. The results are shown in Fig. 16. Comparison with Fig. 1 shows that the desired pattern has been obtained.

Conclusion

The results obtained at radio station KDYL show that either the method of measuring fields of the actual array or the model method may be used to furnish data for designing the phasing and matching networks. The model method may appeal in some cases because the measurements may be made before the actual towers are erected. Also, where one tower is between 0.3 and 0.4 wavelength tall, neither grounding nor floating of this tower will entirely remove it from the picture when the field intensity per ampere factor of the remaining antenna is being measured on the actual antenna system.

On the model antenna system, either tower can be removed at will. However, the use of models requires a large area clear of obstructions, as well as a high-frequency oscillator, receiver, recorder and turntable. If all of this equipment is not readily available, one may be strongly attracted to the method of measuring field intensities on the actual array.

Appendix

Determination of the Effective Field Phase Angle from Field Intensity Measurements:

The field intensity at measuring point A (Fig. 5) is

$$\overline{F}_A = \overline{I}_1 K_{A,1} + \overline{I}_2 K_{A,2} \angle + \Delta + kd \quad (1a)$$

and the field at measuring point B is

$$\overline{F}_B = \overline{I}_1 K_{B,1} + \overline{I}_2 K_{B,2} \angle + \Delta - kd \quad (2a)$$

where Δ is the angle by which the field from tower 2 *leads* the field from tower 1, d is the spacing between the towers, λ is free space wavelength, and kd is $2\pi d/\lambda$ radians or 360 d/λ deg. Then

$$F_A^2 = (I_1 K_{A,1})^2 + (I_2 K_{A,2})^2 + 2I_1 I_2 K_{A,2} K_{A,1} \cos(\Delta + kd) \quad (3a)$$

$$F_B^2 = (I_1 K_{B,1})^2 + (I_2 K_{B,2})^2 + 2I_1 I_2 K_{B,2} K_{B,1} \cos(\Delta - kd) \quad (4a)$$

Rewriting these equations, we obtain

$$\cos(\Delta + kd) = \cos\Delta \cos kd - \sin\Delta \sin kd \sin = \frac{F_A^2 - (I_1 K_{A,1})^2 - (I_2 K_{A,2})^2}{2I_1 I_2 K_{A,2} K_{A,1}} \quad (5a)$$

$$\cos(\Delta - kd) = \cos\Delta \cos kd + \sin\Delta \sin kd = \frac{F_B^2 - (I_1 K_{B,1})^2 - (I_2 K_{B,2})^2}{2I_1 I_2 K_{B,2} K_{B,1}} \quad (6a)$$

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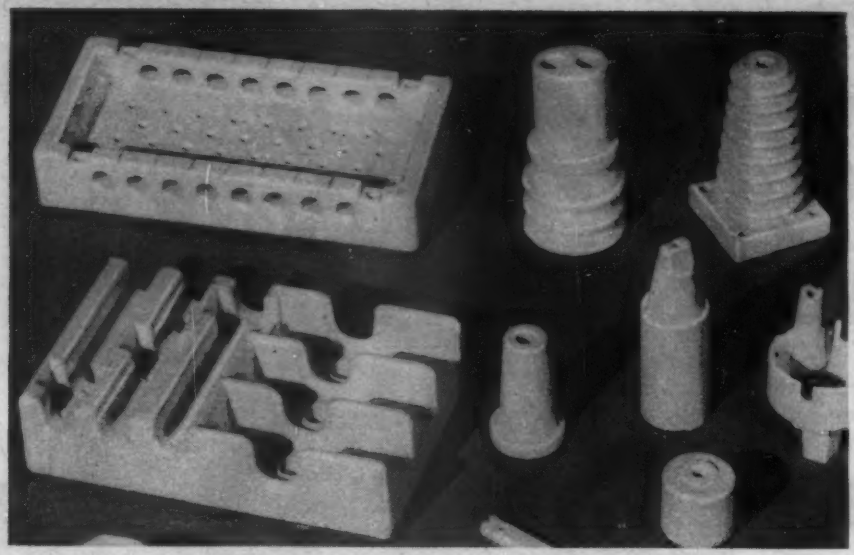

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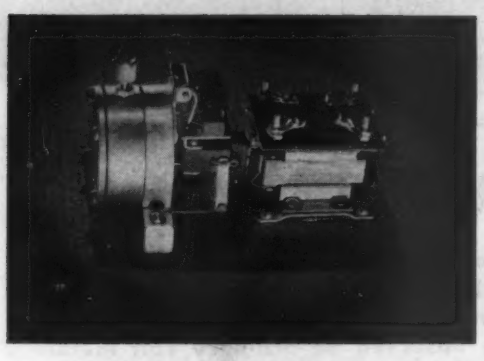

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Adding Eq. (5a) to Eq. (6a),

$$\cos\Delta\cos kd = \frac{[F_B^2 - (I_1K_{B,1})^2 - (I_2K_{B,2})^2]}{4I_1I_2K_{B,2}K_{B,1}} + \frac{[F_A^2 - (I_1K_{A,1})^2 - (I_2K_{A,2})^2}{4I_1I_2K_{A,2}K_{A,1}} \quad (7a)$$

Subtracting Eq. (5a) from Eq. (6a),

$$\sin\Delta\sin kd = \frac{[F_B^2 - (I_1K_{B,1})^2 - (I_2K_{B,2})^2]}{4I_1I_2K_{B,2}K_{B,1}} - \frac{[F_A^2 - (I_1K_{A,1})^2 - (I_2K_{A,2})^2]}{4I_1I_2K_{A,2}K_{A,1}} \quad (8a)$$

These two equations may be used to find the sine and the cosine of the angle Δ. The two equations are needed to determine the correct quadrant. When the spacing between the antennas is an odd multiple of 90 deg., Eq. (7a) disintegrates, and Eq. (8a) alone is useful. Under this condition, we may determine the sine of the angle Δ, but we need further information to establish the correct quadrant. To find the quadrant, we must establish another measuring point, C, on a line which is perpendicular to the line of towers. At this point, the field intensity is given by the relation

$$F_C^2 = (I_1K_{C,1})^2 + (I_2K_{C,2})^2 + 2I_1I_2K_{C,2}K_{C,1}\cos\Delta^\circ \quad (9a)$$

or

$$\cos\Delta = \frac{F_C^2 - (I_1K_{C,1})^2 - (I_2K_{C,2})^2}{2I_1I_2K_{C,2}K_{C,1}} \quad (10a)$$

The angle Δ is then determined by Eq. (8a) and Eq. (10a).

Another unfortunate case is that in which the towers are spaced an even multiple of 180 deg. apart. Then Eq. (8a) is useless. In this event, the measuring points A and B should each be displaced from the line of towers by an angle ϕ. Then Eq. (7a) and Eq. (8a) may be used directly, except that $kd\cos\phi$ is first substituted for kd.

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TIME itself is the most critical of all our needs today . . . . time to make ready the tools and weapons that will insure Victory. We cannot stretch the hours and minutes that lie at hand. But we can borrow from the fruits of the time that has passed — from the years of research stored up by American enterprise.

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The same is true of Simpson electrical instruments and testing equipment. They incorporate all that has been learned in the 30-odd years Ray Simpson has devoted to instrument design and manufacture . . . . all the experience and know-how of a group of men who have long been associated with him. The biggest single example of what this has achieved is the full bridge type movement with soft iron pole pieces found in every Simpson Instrument. It is an acknowledged finer type of movement refined to its highest expression, and so designed that it permits for the first time all the economies and speed of straight line production.

For today's vital needs, this enables Simpson to build instruments of inherent greater accuracy and stamina, at an unprecedented pace. In the postwar tomorrow, you can rely upon Simpson experience to translate and best apply the many things learned under the impetus of war . . . . to provide the utmost in lasting accuracy and instrument value.

SIMPSON ELECTRIC COMPANY
5200-5218 W. Kinzie Street, Chicago 44, Illinois

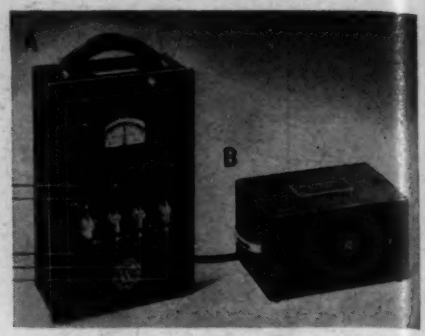
Simpson

INSTRUMENTS THAT STAY ACCURATE

Buy War Bonds and Stamps for Victory

NEW PRODUCTS

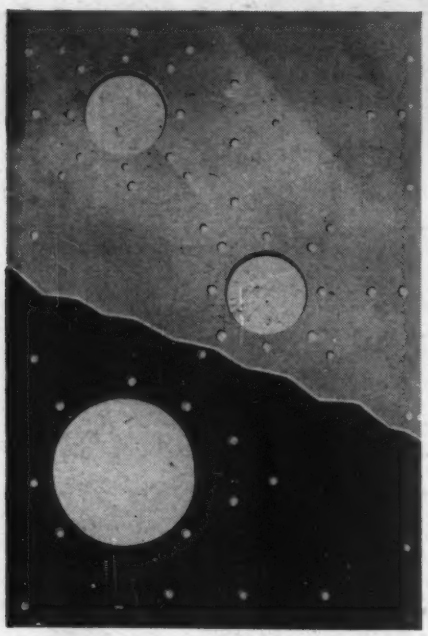
Month after month, manufacturers develop new materials, new components, new measuring equipment; issue new technical bulletins, new catalogs. Each month descriptions of these new items will be found here



Model MW-2

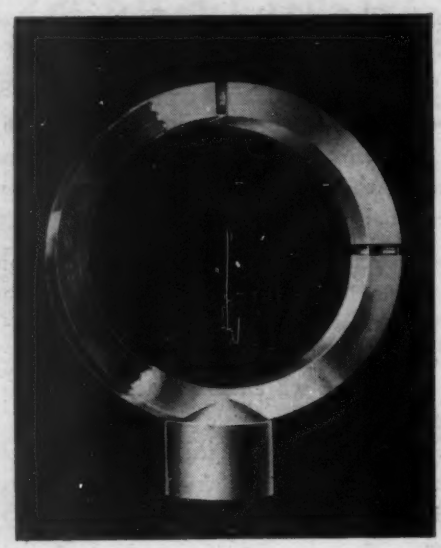
Plating on Plastics

AFTER A GREAT DEAL of research and development, Metaplast Corporation, 205 West 19th Street, New York, N. Y. announces that its method of electroplating metals on non-conductive surfaces is now ready for wide use. This process makes it possible to make platings of any desired thickness, maintaining the detail of the underlying surface. The deposit is non-porous, is smooth and of course adhesive in nature. The characteristics of the deposits may be changed to suit the requirements. Thus it may have high conductivity, high resistance to vibrational stresses or high dimensional stability.



Plating applied to insulating panel

The method saves weight and critical materials, eliminates machine work involved in manufacture of complicated metal housings. For example a loop antenna in a polystyrene casing may be electroplated for electrostatic shielding properties. The final part may be a very oddly shaped plastic, and the plating may still be applied.



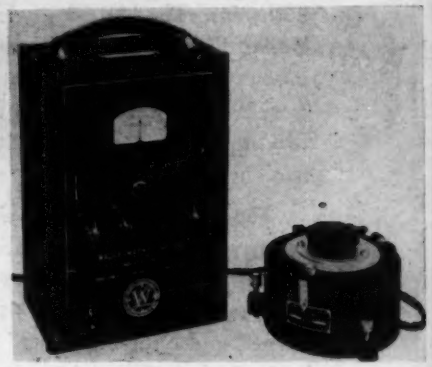
Loop in polystyrene plated for electrostatic shielding

Applications include the design of insulator and conductor as an integral piece as well as instrument housings, collector rings and commutators, uhf reflectors and dipoles, wave guides, condensers, coils and airplane members.

Magnetic Meters

THE TWO INDICATING instruments described below are designated as Magnetometers. Each model consists of an indicating unit and a pick-up unit. The indicating units have a switch by which the range of the instrument can be increased by multipliers of 10 and 30, giving full-scale deflection of 300 and 900 milligausses.

Model MW-2 is an inspection type instrument used to determine the magnetic fields produced by residual magnetism in materials, members and parts for example in permanent magnets where it is desirable to maintain uniform magnetic properties; or to determine strength of undesirable residual magnetism in parts or members such as in aircraft compasses. The instrument will measure, in milligausses or in degrees of deflection, the magnitude of the field strength due to residual magnetism a member would produce on a compass. The indicating unit of the instrument consists of a stabilized, low-gain amplifier and an electronic bridge for indicating field strength and polarity. The pick-up unit supplies the controlling signal to the indicating unit.



Model MW-3

Model MW-3 is a portable, compass adjuster or aircraft analysis type instrument used to measure the strength and polarity of the magnetic field produced by magnetized members, armament, electrical circuits or motors within aircraft. The pick-up unit is responsive to the magnetic field strength. The indicating unit indicates the reading obtained from the pick-up unit. The pick-up unit is fitted with levelling screws and bubble tubes to accurately level the unit in the plane. A pair of sights provide means of orienting the

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tubes
shapes
tapes
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Synflex Compounds as developed in our own laboratories are produced only in the form of rods, tubes, shapes, tapes and elastics. These distinguished materials meet and surpass the most exacting requirements of the electrical and aviation industries. Many formulations are available, each for a specific job.
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PL-54
JK-26

pick-up unit with the longitudinal axis of the plane. A dial, graduated from zero to 360 degrees, permits measurement, in degrees of deviation of the compass, of the magnetic fields. The indicating unit is power-operated from a 115-volt, 60-cycle, a-c source, and includes a low-gain amplifier which is stabilized by inverse feed back. The amplifier feeds an electronic bridge network to which the indicating meter is connected. The meter of the indicator is a zero-center meter with a full-scale deflection on either side of center of 30 milligausses. While the instrument is designed primarily for magnetic control of the air frame, it may also be used as a general purpose precision instrument for magnetic measurements.

Also available is Model MW-4 which utilizes a miniature, self-leveling pick-up unit which may be inserted in a 3-inch diameter opening in the pilot's panel or may be used in other locations where the space is small. This unit is available for operation on either 60 or 400-cycle, 115-volts, a.c.

Waugh Laboratories, a division of Waugh Equipment Company, 420 Lexington Ave., New York, N. Y., or 180 East California St., Pasadena, Cal.

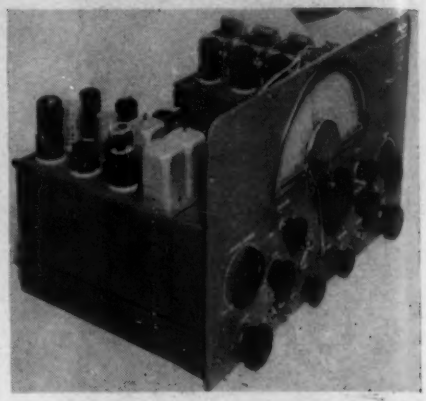
Dynamic Braking Relay

RELAY TYPES 68HX100 and 67HXX-100 make possible instantaneous dynamic-braking with split-series field motors. Designed to give positive action with less weight and simpler mechanisms for a wide range of aircraft and other applications, the relays may also be used in the operation of retractable landing gears, wing flaps, trim tabs, bomb bay doors, hoists, and similar applications utilizing reversing motors. When the relay is used in winch operations, a simple locking dog may be used instead of a large magnetic brake. Positive contacts select the proper field winding to give reverse torque for braking. There are no sliding contacts, and all parts and contacts are readily accessible for inspection. The relays operate in all positions, and withstand salt-spray, vibration and altitude tests.

Struthers-Dunn, Inc., 1321 Arch St., Philadelphia, Pa.

Communication Receiver for Ground Stations or Shipboard

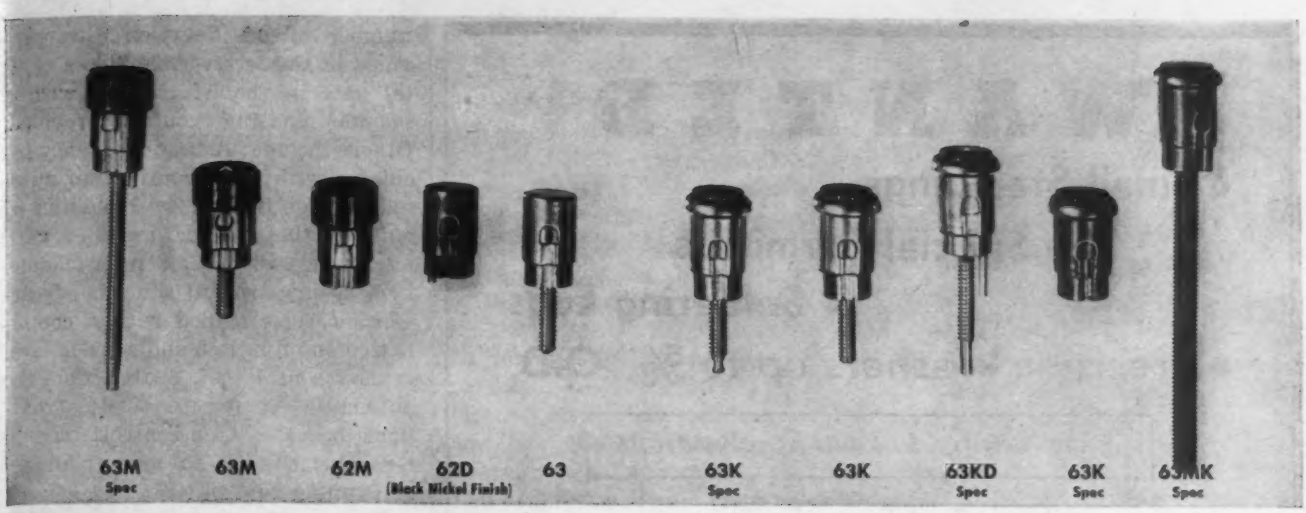
MODEL HM-10 COMMUNICATION receiver features what the manufacturer calls "Unitized" cells which are self-contained, replaceable circuit elements. The cellular construction developed by the manufacturer permits rapid assembly of practically any type receivers from three basic cells.



In Model HM-10, eight cells mounted on a common chassis constitute the receiver, with an additional power supply cell based on individual installations. Four of these are r-f cells and are located on the right side of the chassis, in which four bands of tuned radio frequency are provided; two i-f cells and two audio cells are placed on the left side of the chassis. Connecting each cell to the other are nine bus bars, which eliminate the need for conventional wiring between circuit elements. An optional power supply cell is located between the two groups of four cells. This power-supply cell is available in 6, 12 or 24 volts in either a dynamotor type or in a vibrator type, or 110 volt, 50–60 cps, a.c.

Another feature of the receiver is the r-f coil assemblies of the rotating turret type. Model HM-10 has four r-f bands, with four r-f coils wound over molded Lucite forms. Each coil is provided with solid silver contacts. The contact points on the coils wipe against matching tumblers supported by the cell-box.

The four standard bands in the receiver are 1.49 to 2.67 Mc, 2.625 to 4.55 Mc, 4.50 to 7.80 Mc, and 7.70 to 12.55 Mc. The i-f selectivity is not less than 6 kc for a 10 db attenuation with the crystal in "off" position. A



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ASSURE A POSITIVE VIBRATION-PROOF CONTACT!

1. The spring — unseen but most important, is designed for long life with minimum pressure loss in service — corrosion resistant.
2. The "D" shaped hole grips the finest wire and holds it in perfect contact. This special Eby construction gives correct, uniform tension across the entire surface of the wire.
3. Eby spring posts have dual guides — makes positive alignment of insertion holes.
4. Made from the highest quality material to meet rigid manufacturing standards and assure maximum electrical conductivity.
5. Recognized standard finishes are nickel, silver, black nickel, and cadmium.
6. Insulating bases, shields, bushings, and spacers in bakelite and ceramic.
7. Cap markings are supplied such as: ANT; REC; GND; HI; A; C; Line; —; +; L1; L2.
8. Most items are carried in stock in sufficient quantity to assure quick preliminary deliveries.

Eby Spring Binding Posts are made to a traditional standard of quality and workmanship, backed by years of experience and a long list of satisfied users. The actual styles shown are illustrative of the wide variety and the great possibility of the use of Eby Spring Binding Posts.

A BINDING POST FOR EVERY USE!

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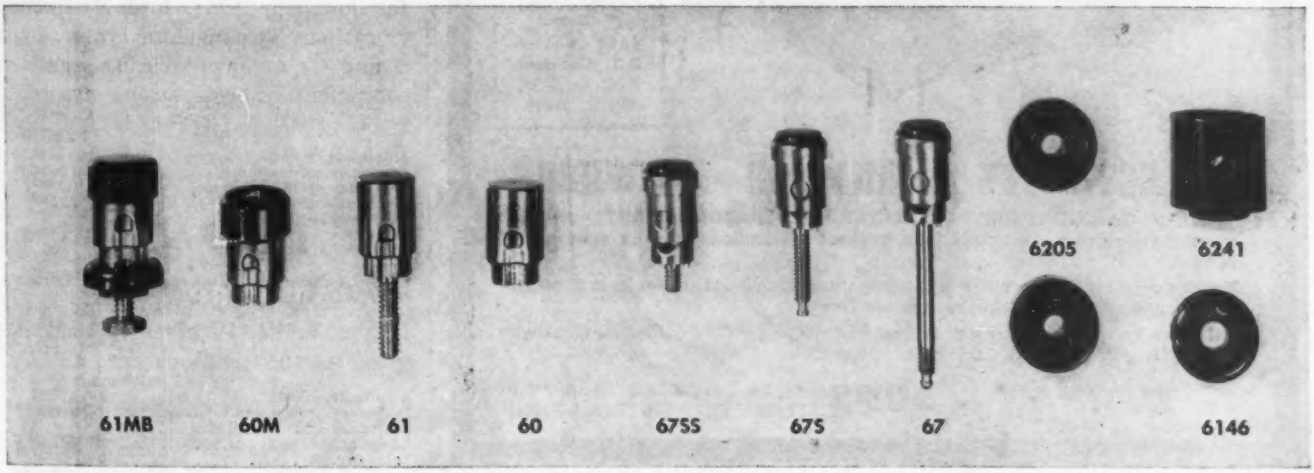

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Large Tool Room Facilities
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HIGH GRADE STAMPINGS
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on Medium and Large Quantities

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Phone: WELlington 4202

ONAN
ELECTRIC PLANTS

Awarded to each of the four Onan Manufacturing Plants

Ratings from 350 to 35,000 watts. 50 to 800 cycles, 110 to 660 volts, A.C. — 6 to 4000 volts, D.C. Also dual A.C. — D.C. output types.

ELECTRICITY for ANY JOB—ANYWHERE

★ ONAN GASOLINE DRIVEN ELECTRIC GENERATING PLANTS provide electricity for many electronics jobs, general applications, and for emergency service.

They're doing a war winning job today, furnishing vital power and light for scores of war tasks on all the fighting fronts.

Your inquiry regarding present or post-war needs for ONAN Electric Generating Plants will get prompt attention.

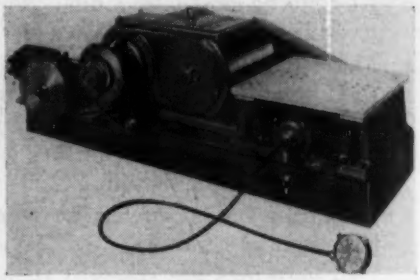
D. W. ONAN & SONS 1926 ROYALSTON AVE., MINNEAPOLIS, MINN.

number of auxiliary circuits, provided in the receiver, include a crystal gate in the i-f channel with a manual phasing control provided. Others include: A beat-frequency oscillator with pitch control; an automatic noise limiter for reduction of noise at the detector, provided with an off-on switch; an inter-channel noise suppressor to squelch off-carrier noises, provided with a combination on-off switch and squelch level control; an on-off switch for the automatic volume control; front-panel operated tone control; manual r-f gain; manual antenna trimmer; and tuning control lock.

Harvey Machine Co., Inc., 6200 Avalon Blvd., Los Angeles 3, Cal.

Vibration Testing Machines

THESE VIBRATING MACHINES are designed to produce horizontal, vertical and circular motion at high frequencies, and may be used for breakdown testing of any apparatus normally subject to vibration failure. Three types, V.M.J-2H, V.M.J.-4V and V.M.J.-3C are available.



Type V.M.J.-2H

Type V.M.J.-2H gives horizontal motion and is especially designed for low amplitude, high frequency vibrations. Two machine types (Type B and C) are available as standard equipment. Specifications are:

	TYPE B
Amplitude, inches	0 to 0.0625
Frequency, cycles/min.	600 to 3600
Frequency cycle period, min.	1*
Accelerations	12 g**
Table capacity, lb.	150
Table area, in. x in.	18 x 18½
Weight of Machine, lb.	800

* May be altered to suit the requirements of product.
** Type C, 32 g.

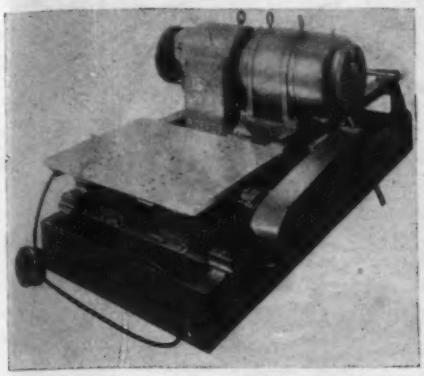
Type V.M.J.-4V gives vertical motion. Its specifications are:

Amplitude, inches	0-0.0625
Frequency, cycles/min.	600-6000**
Frequency cycle period, min.	1*
Accelerations, max.	12.6
Table capacity, lb.	100

Table area	18 x 24 inches
Weight of machine, lb	800

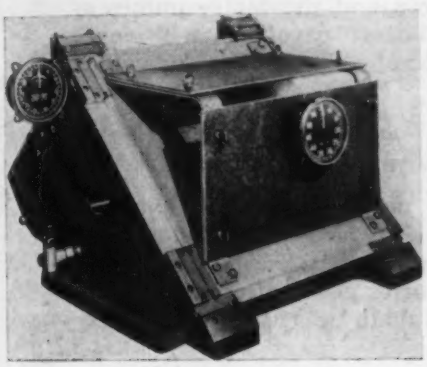
** Two sets of quick-change pulleys provide frequencies of 600–3600 and 1200–6000.

Some of the items which may be tested are aircraft and tank radios,



Type V.M.J.-4V

radio accessories, dynamoters, contactors, flexible tubing, magnetos, quartz crystals, instruments and other devices for military service.



Type V.M.J.-3C

Type V.M.J.-3C has circular translatory motion. It was built from designs developed by the U. S. Bureau of Standards. This machine fulfills the requirments for tests of aircraft instruments such as altimeters, pressure gages, speed indicators, bomb selectors, turn and bank indicators, clocks and compasses. Specifications are:

	TYPE C*
Amplitude, inches, ½ dia. of circle on 45° plane	0–.031
Frequency, cycles/min	200–3000
Acceleration	10.9
Table capacity, lb. on 45° plane	25
Table capacity on horizontal or vertical plane	10
Table Area, in. x in. 45° plane	24 x 24
Table Area, horizontal or vertical plane	12 x 16
Weight of Machine, lb	450

* Type "B" machine is identical to type "C" except that three fixed frequencies are furnished instead of the variable control.

Waugh Johnson Associates, Inc., Ithaca, N. Y.

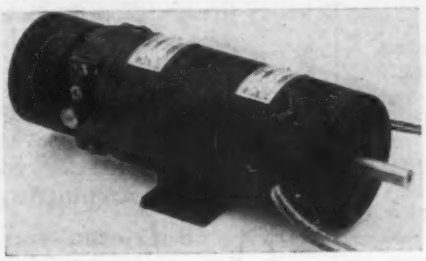
Cyclometer-Type Counter Assembly

ALTHOUGH DESIGNED for registering rotary coil turns, this counter unit is adaptable to most applications where a shaft must be turned a predetermined number of times, or set at any pre-determined position. The exact number of turns, down to tenths of a turn, are recorded on the counter. Standard counters record 10 turns, other counters available record up to 100–1000 turns. Contacts at any desired inductance value may be quickly and easily set when the counter is used with rotary coils. The counter assembly includes a direct shaft drive (1:1 drive shaft to driven unit). Shafts can be of any length. The gear drive is direct, with precision cut steel gears. The counter itself is a Veeder-Root product. The unit weighs 8 ounces, and is available with either right or left hand rotation. It can be supplied with name plates to suit the application.

Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.

Motor-Generator

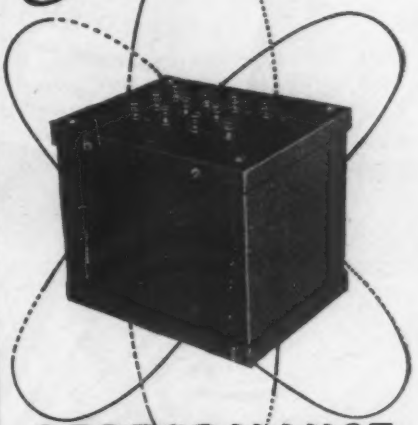
MODEL L32 MOTOR-GENERATOR is available in either standard models which operate on 6 volts, d.c., input, or in models rated at 12, 24 or 115 volts, d.c., input. The a-c output ratings (which vary with the speed) are 1, 2 or 3 phase. A standard model includes a speed regulator and resistance. A speed governor is available, if desired. The speed is controlled



within 1 percent for 25 percent variation in the input or the load, and the generator is capable of delivering power rated at 27 volts, 2-phase, a.c., at 2400 rpm. The unit is base mounted, measures 6¼ inches long, and is 2 inches in diameter. It weighs 32 ounces. It is equipped with a single ⅛-inch shaft, with a 1-inch shaft extension which protrudes from the front of the case.

Electric Indicator Co., 110 Parker Ave., Stamford, Conn.

Electronic



PERFORMANCE

Imagine splitting an ampere into thousandths. But, that's our business, for electronic performance depends upon controlling electrical impulses to close limitations. If you use transformers with micrometer-type specifications, better talk with an Acme Engineer. We know how to build Plate Supply transformers, Power transformers, Filament transformers, Chokes, etc., and for all electronic applications.

Maybe you need something like this. 2½KVA. Auto transformer, 115 volts primary, 90/100/110/120/130/200/210/220/230/240 secondary.

BREAKDOWN TESTER

A compact, portable testing unit ideal for laboratory or production-line use, 115 volt, 60 cycle primary. Adjustable secondary voltage of 500/1000/1250/1500/1750/2000/2500 volts. Many safety features combined with typical Acme high quality construction . . . Write for Bulletin 140.

THE ACME ELECTRIC & MFG. CO.
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Acme Electric
TRANSFORMERS

Have you ever been out of a job?

What you can do

The best way to insure good jobs and better living is to create an environment favorable to continuous industrial progress.

The best way to insure healthy industrial progress is through a nation-wide understanding of the fact that we live better through doing more work in less time.

Nation-wide understanding of that fact will result in laws that encourage industrial progress.

Nation-wide understanding always will be a will-o-the-wisp, unless each business man does his share of: (1) Understanding his own responsibilities in maintaining industrial progress; (2) Explaining the relation between *good* business and good living to his employees and neighbors.

The newspaper advertisement reprinted here is McGraw-Hill's share in the job of explaining the source of good living. It has appeared in Washington, New York and Chicago, as well as in all McGraw-Hill publications. It is available, for use over your own company signature, in your plant city. A mat, six-column size for newspaper reproduction, will be sent to you upon request. Booklet reprints are also supplied at cost ($10.00 per thousand).

James H. McGraw, Jr.

President

McGraw-Hill Publishing Company, Inc.

IF you have ever been out of a job, and if you had a wife, children and slender resources at the time, then the fattest paycheck will never quite obscure the memory of the days and nights you lived with fear.

Some of that fear lingers in every man's mind, for all have suffered in some degree.

► That's why you hear the words "postwar planning" so often. Americans are determined that, one way or another, they are going to keep our thousands of factories going after the war, so that there will never again be a vast army of unemployed.

As usual, in a democracy, there are two entirely different ideas as to how to make 56 million jobs grow after the war, where only 46 million existed before.

Both kinds of people, who hold these different ideas, sincerely want to make the postwar world a better place for you to live in. They have complicated arguments, backed by lots of figures.

But when you trim all the arguments and figures down, you find that one side believes in DIVIDING jobs to make them go round, and the other side believes in MULTIPLYING jobs so there will be greater opportunity for all.

We believe in the MULTIPLYING plan for making postwar jobs and ask you to believe in it too.

Look back over our history. What made us great? Was it rich soil? Africa's is as rich. Was it

[FREE MATS: If you would like to publish this message over your own company name, or distribute it in handy booklet form, write or wire: Research Dept., McGraw-Hill Publishing Co., Inc., 330 West 42nd St., New York (18), N.Y.]

Have you ever been out of a job? (cont'd)

natural resources? China has them in abundance.

NO, the greatness and the good living of America is the direct product of her genius for doing more work in less time.

Invention is the source of improvement, and *improvement* is the multiplier of jobs . . . when products are improved in service or style, or lowered in price, new customers are attracted and new jobs created.

That's why it is true that good living has its source in industrial progress.

When industrial progress is interrupted, we have a depression, and there is less good living.

When (through courageous investment in new and better products) industrial progress is resumed, we go on to even higher levels of good living.

► If every able-bodied person in America is to have a job, then we must all understand the things that make good living possible, and we must all help *improve* the methods that have given so much good living to so many people already.

For businessmen, that means a constant search for improved methods and machines, a regular year-after-year investment in industrial progress. This means avoidance of such things as speculation in inventories that tend to create booms and depressions rather than consistent progress.

For every citizen, it means a constant search for the best ways and means to prevent and cure depressions.

Businessmen, alone, cannot prevent bad times. It's a job for *every* citizen. Every American can help just by knowing that good living comes from doing more work in less time. If you, and all other Americans, swing on to that fact, the laws that control our rate of industrial progress will be better designed to keep the improvement engine running.

That's where government really can be helpful in postwar planning.

It can encourage the "take a chance" spirit that is the basis of all progress. And it can improve the measures which prevent and cure depression. At present, our laws are not framed to encourage investment in new and better methods.

Many local, state and national taxes work out in favor of keeping an old machine, instead of buying a new one.

► There are tens of thousands of machines in the country that are over 20 years old. Even our shiny new war equipment is living 3 years in one, and will be old when the war is over.

Every machine should be regarded as obsolete as soon as it is installed and work started on a better one. In the long run, that is the best way to multiply jobs and create better living. Our laws should *encourage* the process, not *discourage* it.

New machines can only be bought with the profits created by old machines. The money that is laid aside by industry to develop and buy new machines is called "Seed Money." If laws take away too much of the Seed Money of business, that will prove disastrous. High taxes must be paid, but they should not destroy Seed Money, which is the only source of improvement.

That's why it's so important for everyone, no matter what his walk in life, to know this fundamental fact:

"Industrial Progress is the Source of all Good Living."

THE McGRAW-HILL NETWORK
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24 publications, which gather "war-news" from the "war-production-front" through a staff of more than 153 editors and 725 engineer-correspondents . . . More than 1,500,000 executives, designers, production men and distributors use the editorial and advertising pages of these magazines to exchange ideas on war-production problems.

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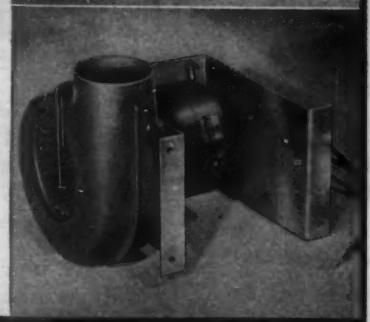

PILOT BLOWERS are produced in five standard sizes with output ranging from 49 to 162 C.F.M. Among the innumerable applications for these dependable, low-cost Blowers are: *Forced Draft, Air Distribution* in Refrigeration systems, *Exhausting* fumes or gases, *Cooling* for Radio or Electronic Equipment, *Heating, Drying,* etc.

Special Blowers employing custom-built Pilot Motors are designed to deliver any quantity of air from 12 to 200 C.F.M. A request on your company letterhead will bring complete information. Write today!

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Pilot BLOWERS

MADE BY THE MAKERS OF THE FAMOUS PILOT FRACTIONAL H. P. MOTORS

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FOR EVERY RADIO ELECTRICAL AND ELECTRONIC USE

Fabricated parts for electronic tube and condenser manufacturers—including discs, bridges, supports, stampings in any shape or form, condenser films, etc. We are serving hundreds of leading companies since 1917. Special attention has been paid to radio tube and component manufacturers since the early days of the radio industry.

Our complete manufacturing facilities, experience and the quick understanding of our customers' problems, blend to make our service invaluable to an increasing number of new clients.

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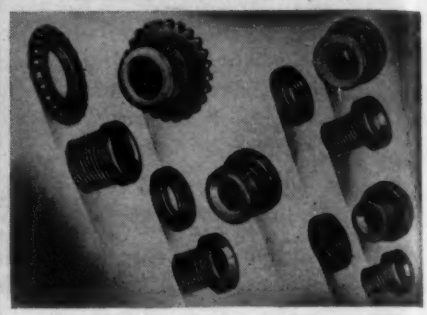
FORD RADIO & MICA CORP.
Joseph J. Long, President
538 63rd Street Brooklyn, N. Y.
Established 1917 • *Telephone:* Windsor 9-8300

Plastic Insulating Grommets

THESE GROMMETS ARE available in four standard sizes and have been developed for use by radio, motor and electronics manufacturers, and are designed to save assembly time operations. They are matte finished. The



holes are concentric with chambered corners to avoid wire chafing. The threads are clean and are lubricated.

Creative Plastics Corp., 970 Kent Ave., Brooklyn 5, N. Y.

Improved Kelvin Bridge

MODEL K-1 KELVIN BRIDGE incorporporates an a-c (60-cycle) bridge source voltage, and uses an electronic null indicator in place of a galvanometer. The equipment is completely self-contained in a single cabinet and is particularly useful for routine measurements in production, or in a laboratory, on low-resistance elements such as fuses, fuse clips, switch contact, wire, bonds and similar items. The source voltage is rated at 0.05 volt and the over-all accuracy is within ± 2 percent, except for resistance values below 0.0005 ohm. The accuracy at the lowest resistance that can be measured is 0.0001 ohm, ± 5 percent. A standard resistor decade (designated as DR-20), having 10 settings ranging from 0.001 to 1.0, is available with the instrument. Measurements on the bridge are obtained by the rotation of a dial which is directly calibrated in resistance. The dial readings are multiplied by a factor determined from the setting of the standard resistance switch. Several hundred tests per hour (with suitable test fixtures) may be obtained; the instrument can be operated at high speeds by semi unskilled personnel.

Industrial Instruments, Inc., 156 Culver Ave., Jersey City, N. J.

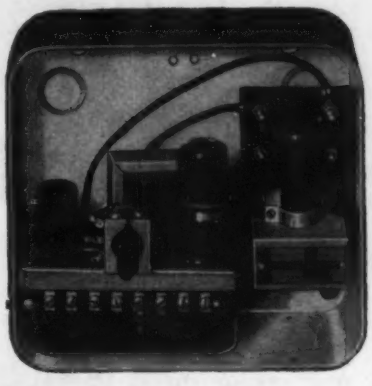
400-Cycle Units

EASTERN AIR DEVICES, INC., (585 Dean Street, Brooklyn 17, N. Y.) specializes in control devices, especially in 400-cycle motors for electrical, electronic and mechanical applications. Some of the motors available include the following: Model J31, rated 1/50 hp, single-phase capacitor; J31A, 1/100 hp, single phase capacitor; J33, 3-phase, synchronous; and a high power induction motor. Other products available include a d-c to 400-cycle a-c inverter; a wide range, constant speed, d-c motor; a permanent magnet field d-c voltage generator; and a vibration-proof relay.

Performance characteristics of Model J33, 3-phase, synchronous motor mentioned above are as follows: Voltage, line-to-line, 115 volts; speed 8000 rpm; phase current 340 mils; synchronous pull-in torque 0.6 ounce-inches; synchronous pull-out torque 1.0 ounce-inches; stall torque 2.2 ounce-inches; phase current at stall 650 mils; weight 16 ounces.

Adjustable Electronic Time Relay

THIS RELAY IS a hermetically sealed unit which is safe in explosive and corrosive atmospheres. The only moving part is a fast-operating steel-encased plunger which works in a hydrogen pressure atmosphere. Time settings are continuously variable



within the range and may be adjusted to precisely the required operating point. Standard model relays cover time ranges from 0.05 to 0.5, 0.10 to 10, and 1 to 100 seconds respectively. Special models with time ranges up to 5 minutes are also available. Contact capacities are available up to 75 amps, either normally open or normally closed.

Durakool, Inc., Elkhart, Ind.

AT CARDWELL, we deal with truisms. Here . . . fresh, sound, original designs are combined with materials of merit, and collated by skilled craftsmen . . . for use in practically every type of communications equipment — amateur, commercial and military.

Material things, however, are not sufficient to make Cardwell condensers the quality products that they are. Into them go an additional ingredient—a heritage of pioneering, patience and judgement.

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CERAMIC RESISTORS

RESISTORS are, in the final analysis, energy dissipators and as such they should be rugged. Since the demands of electronic circuits are quantitatively exacting, a resistor should be electrically and mechanically stable. Ruggedness and stability in a resistor gives assurance that it will retain indefinitely its established resistance value under normal loading.

A good resistor should withstand, without suffering a permanent change in resistance, the maximum accidental over-voltage to which it might be subjected in service. Moreover a resistor should be relatively free from microphonic effects, inductance and capacitance and it should not be affected by humid atmospheres.

"Globar" Brand Ceramic Resistors meet these specifications. Right now deliveries must be scheduled according to priority ratings and date of order. Nevertheless we invite you to tell us about your needs; we pledge our best efforts to assist you.

The condensed table below gives you at a quick glance the physical and electrical characteristics of the more commonly used industrial type "Globar" Resistors.

TYPE		A	B	CX
LENGTH	Min.	¼"	¼"	¼"
	Max.	18"	18"	18"
DIAMETER	Min.	1/16"	1/16"	1/16"
	Max.	1"	1"	1"
RESISTANCE Per Inch of Length	Min.	2 ohms	0.5 ohms	0.05 ohms
	Max.	0.25 meg.	1 meg.	100 ohms
*OVERALL WATT RATING	Max.	54 watts	54 watts	150 watts
*NORMAL RATING W./Sq. In. of Radiating Surface		1 watt	1 watt	2.5 watts
MAXIMUM VOLTAGE Per Inch of Length		400 v.	400 v.	**Note

*These ratings may be substantially increased by artificial cooling.

CHARACTERISTIC COEFFICIENTS:

TYPE A: Comparatively Straight Line Temperature and Voltage.

TYPE B: Negative Temperature and Voltage.

TYPE CX: Slightly Positive Temperature.

Other resistor types are available for specialized applications.

TERMINALS: Metalized ends for clip mounting or wire leads.

** Type CX has low specific resistance and cannot be subjected to voltage stresses permissible with Types A and B. Maximum allowable voltage is that required to yield maximum watt rating.

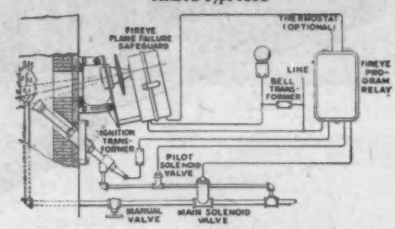
Globar Division
THE CARBORUNDUM COMPANY
REG. U. S. PAT. OFF.
NIAGARA FALLS, N.Y.

(Carborundum and Globar are registered trade-marks of and indicate manufacture by The Carborundum Company)

Photoelectric System for Flame Failures

FIREYE TYPE F28C is a photoelectric system for providing instantaneous fuel-cut-off in any pressure-fed burner in the event of flame failure. It is capable of monitoring flames of any intensity in oil, gas, or pulverized coal burners, and operates entirely from direct observation of the flame itself. The monitor is normally used with manually-ignited burners to cut off fuel and sound an alarm,

FIREYE Type F28C



Typical FIREYE Installation For Automatically Ignited Oil Burner

but when used with Program Relay, Type R25, in burners which are automatically fired, the instrument will program the fuel and pump operation, the intermittent ignition system, purging period, and the recycling. Designed to operate at relatively high ambient temperatures, the monitor is mounted directly on the furnace wall and watches the flame through a window in the wall of the fire chamber.

Combustion Control Corp., 77 Broadway, Cambridge 42, Mass.

High-Altitude Oil Capacitors

MANY TESTS AND STUDIES of terminal breakdown voltages in high altitudes have resulted in the manufacture of a new series of high-altitude oil capacitors by Aerovox Corp., New Bedford, Mass.

One of these capacitors is similar

NEW OBJECTIVES QUICKLY GAINED

BELL SOUND SYSTEMS

Like a trained attack force striking swiftly and surely at new objectives, Bell Sound Systems forged ahead with fast action in taking over wartime needs for electronic equipment. As pioneers in the development of improved systems for inter-communication, amplifying, recording, and other purposes, BELL has always adhered to a policy of progressive experiment and research. This habit of looking and thinking ahead gives BELL engineers a head start on new requirements. Because still further knowledge of how electronics can serve a peacetime world is being gained from this wartime production, you can look to BELL Sound Systems, Inc. for leadership after Victory.

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For efficient vocal-paging and plant-wide broadcasting of announcements, signals, recorded music—the *first, complete* system of *standard* units designed for *industrial* needs. Quick, easy expansion or rearrangement; adjustable to any variety of noise levels; standard units combine to fill needs of any type or extent. Write!

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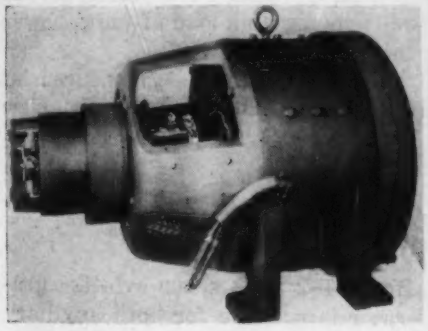
1189 ESSEX AVE., COLUMBUS 3, OHIO
Export Off.: 4900 Euclid Ave., Cleveland 3, Ohio

to the standard Aerovox Type '12 round-can barrier-cap units, except that one terminal is a short screw post while the other terminal is a tall insulator post with a corona shield at the top. The cover assembly is a one-piece ceramic cap, with the can top spun over a rubber gasket and the cap to assure hermetic sealing. The arrangement of terminals, corona shield and ceramic cap is designed to minimize surface leakage, corona losses and probability of voltage breakdowns at extreme altitudes. These new aircraft, Type '12, capacitors use Hyvol vegetable oil for the impregnant and fill. The manufacturer states this special oil tends to maintain effective capacitance at subzero temperatures.

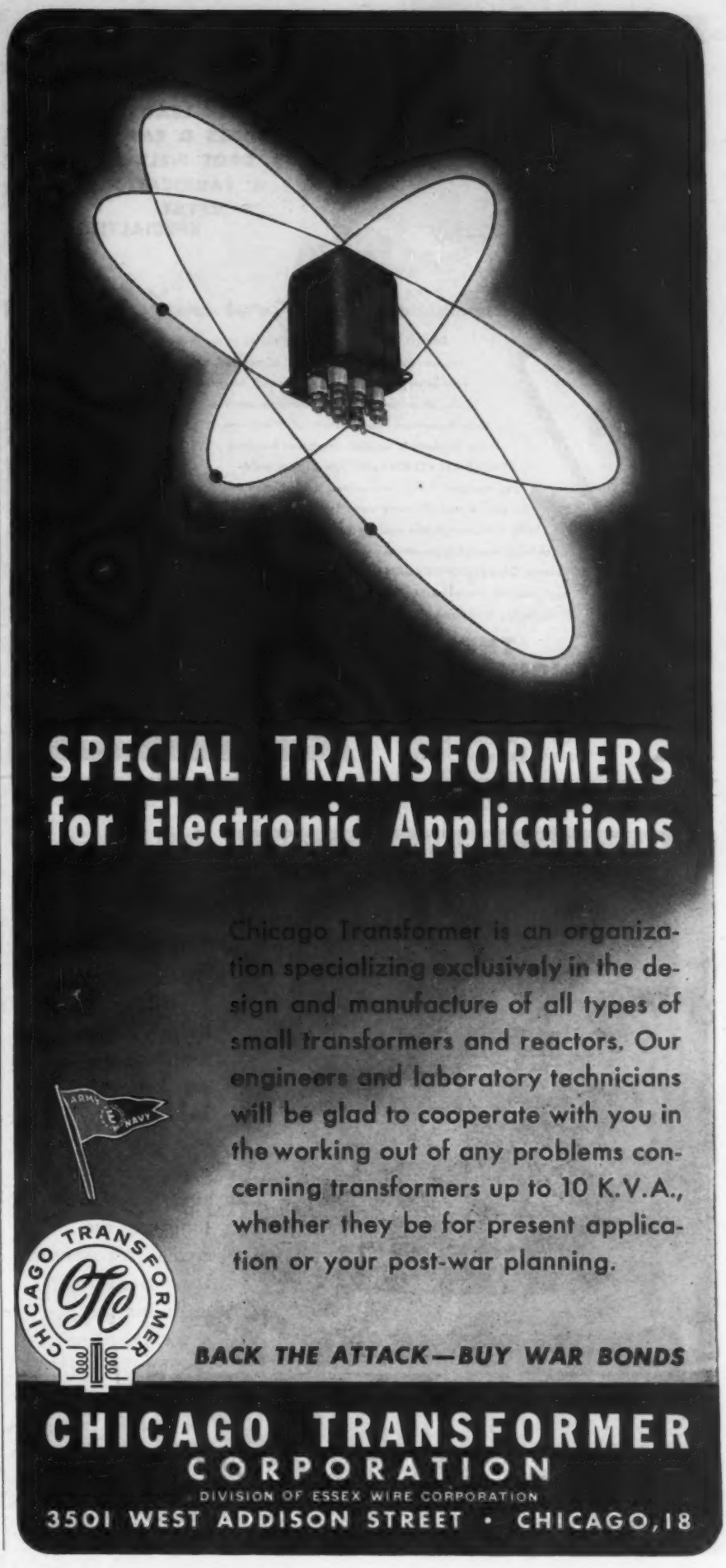
Revolving Armature Type A-C Generator

THE MANUFACTURERS OF Katolight generators have added to their line of products the Model 55 generator, which has a rated capacity of 25 kw at 80 percent power factor, single phase; or 30 kw at 80 percent power factor, three phase. The unit measures 38½x24½x25¾ inches, and weighs approximately 1375 lbs. It is available in standard or special voltages.



The inherent voltage regulation is approximately 10 percent between no load and full load, with 3 percent speed change. It is a six pole, revolving armature type generator with separate excitation and is rated at a speed of 1200 rpm. Damper windings make it suitable for synchronization. Designed for direct attachment to engine bell housing, the generator is also available as an independent unit with standard shaft extension. It is available for clockwise or counterclockwise rotation since all leads are external.

Kato Engineering Co., Mankato, Minn.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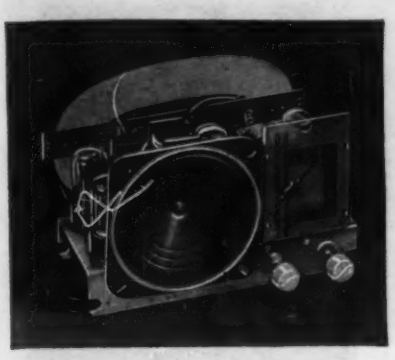
Radio Receiver Kit

THESE 5-TUBE KITS are especially for use for illustrating theory and practices now being covered in basic or pre-induction radio training. The kit is designed to aid students in basic receiver subjects such as rectification, filtering, detection, r-f, i-f and a-f amplification. A kit consists of wire, hardware, solder, tubes and speaker for the construction of a 5-



tube a.c.-d.c. superheterodyne receiver. The chassis is completely formed and punched and is rustproof. The circuit includes oscillator, r-f and i-f stages, contact-potential biased audio stage, inverse feedback, automatic volume control, high capacity filtering and a self-contained antenna.

Allied Radio Corp., Educational Div., 833 W. Jackson Blvd., Chicago 7, Ill.

Aircraft-Type Shockproof Relays

SHOCKPROOF RELAYS designated as "Amar" are stated to be immune from effects of gravity, vibration, centrifugal force, centripetal force, jerks, or shocks. The manufacturer states the relays will function reliably under vibration of any magnitude or degree of acceleration and that there is nothing to get out of adjustment because no heavy spring tension is used on the armature. The relays can be made to specifications regarding contact arrangements, voltages, mounting details, or other requirements. They are adaptable to a wide range of contact arrangements, from SP, ST, up to and including 6 pole, DT; or for series contacts, double breaks, etc.

Automatic Electric Mfg. Co., Mankato, Minn.

The New Genie in a Bottle

Arabian Nights' analogies are left far behind when we talk about the future possibilities of electronic energy in thin glass tubes: the twentieth century genie in a bottle. An incredibly sensitive and positive control of industrial processes is now possible, and every industry must face the probability of technical revolution.

Back of the electron tube, energizing it, is the transformer. Both in war and in peace this mechanism is the special concern of Stancor engineers. Many improvements developed and tested in war, and new developments planned for peace, will emerge from the Stancor laboratory to contribute to post-war industry.

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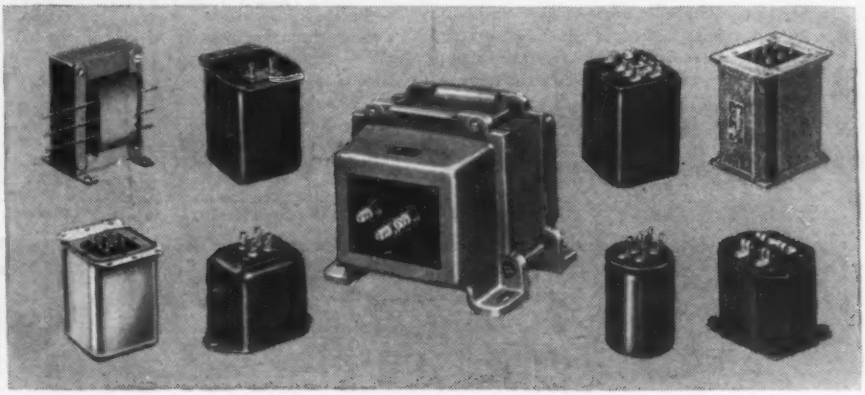

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★ BASES & CAPS
★ SPOT WELDERS
★ FABRICATIONS
★ METAL SPECIALTIES
..available now to meet your needs!
DANIEL KONDAKJIAN capabilities in the precision component field are diversified and specialized. Leading suppliers of tungsten leads, bases and caps for electronic applications—precision manufacture of metal specialty products is another important function. The DANIEL KONDAKJIAN line of spot welding equipment, too, has earned a reputation for service and efficiency since 1922. With three completely equipped plants available for supplying present or post-war requirements, DANIEL KONDAKJIAN invites inquiries applicable to those facilities. Our engineers will be happy to collaborate in your problems.
THE ENGINEERING CO.
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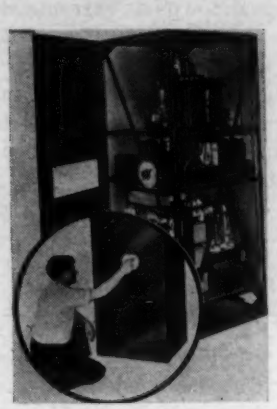
Variable Frequency Electronic Generator

MODEL CML 1400 GENERATOR was developed for applications requiring test power at various loads through a wide frequency range. It delivers power with good regulation and waveform over a frequency range of 300 to 3500 cycles. Other applications of the unit include complete tests on the production line, testing aircraft radio installations in a plane

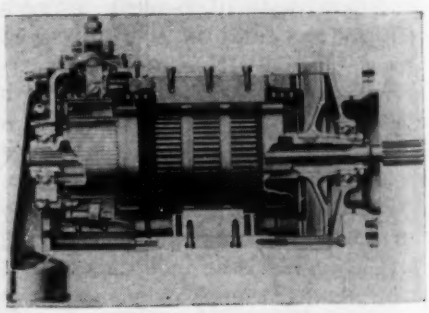


or repair shop, and testing transformers and condensers. The unit includes a variable-frequency oscillator and several driver stages. A special control circuit maintains output voltage at a substantially constant level from no load to full load. The power output is rated 1400 watts at 120 volts rms, with a load of unity power factor.

Communications Measurement Laboratory, 120 Greenwich St., New York, N. Y.

Aviation Generator

MODEL P-2 HIGH SPEED aviation generator is suitable for both auxiliary and main engine applications. It is



rated at 28.5 volts, 200 amps at 5,000 to 10,000 rpm. It weighs 36 lbs.

Eclipse-pioneer Div., Bendix Aviation Corp., Teterboro, N. J.

Brach Marine Antennas and Mounts are now manufactured 100% for the service of Uncle Sam's amphibian tanks, PT boats, etc. But with the dawn of Victory we shall be ready and able to utilize our enhanced experience and wartime "know how" in supplying the civilian requirements for antenna equipment for ship-to-shore communication.

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A simplified manual of radio theory and equipment

This book approaches radio equipment and theory on a purely practical and simplified basis, and omits all mathematics, physics, complicated formulae, and involved graphs. You can start on page one of this simplified book and by following through in your spare time learn enough useful radio principles to start right in doing practical radio work as repairman, technician, or operator.

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BASIC RADIO PRINCIPLES

By Capt. Maurice G. Suffern
Signal Corps, U. S. Army
271 pages, 5½ x 8, 269 illustrations, $3.00

HERE are full explanations of the major radio theories and actual radio equipment to give the practical radio man a thorough understanding of the construction and function of the composite parts of radio equipment.

The manual begins with the most fundamental radio theory, and goes on to more particularized discussions of radio theory and equipment. Straightforward descriptions show how various types of radio equipment are represented diagrammatically, how they are constructed, their various capabilities, and the principles necessary to keep in mind for the best work from all kinds of equipment.

The manual shows how to recognize and interpret radio symbols and understand the way the individual symbols are joined together to form a circuit.

An important book for:

- Men going into the Armed Forces where radio plays a vital part
- Radio operators and radio repairmen who find themselves hampered by a limited knowledge of radio theory
- Applicants for Civil Service radio examinations
- Beginners in radio who, in their spare time, want to learn enough useful radio principles to start right in doing practical radio work

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Tube Substitution Chart. A pamphlet fitting standard size loose-leaf binders and containing charts and data on radio tube substitutions has been compiled by the engineers of Sylvania Electric Products, Inc. The pamphlet includes substitution charts for 150-ma a-c d-c receiver tubes, 300-ma a-c d-c receiver tubes and battery tube types, edited to conform with the WPB civilian radio tube program. Pamphlet available from Sylvania Electric Products, Inc., Emporium, Pa., or Sylvania distributors.

Plastics. Catalog No. 103 presents a variety of plastic parts which the company below is able to supply. Among the items described and illustrated are: instrument knobs, pointer knobs, push buttons, terminal and control knobs, control balls, dials, pointers and headless setscrews. Catalog No. 103 available from Kurz-Kasch, Inc., Dayton, Ohio.

Circuit Tester. Rotobridge, an automatic high-speed mass production tester, is described in a 6-page folder. The folder describes how the Rotobridge detects trouble and errors automatically and checks circuit resistance values as low as 0.001 ohms, with Wheatstone bridge precision. Copies of the Rotobridge folder available from Communication Measurements Laboratory, 116–118 Greenwich St., New York, N. Y.

Metal Stampings. In a large-size, hard-cover book attractively printed in two colors, The Fred Goat Co. Inc. and its affiliates and subsidiaries present Fifty Years of Engineering Achievement by means of a pictorial presentation of a few of the machines and products turned out during this period. These include the Goat satchel-bag packaging machine, automatic carton, tag and label presses, fur marking machine, stampings for electronic tube structures, form-fitting tube shields, small aircraft and electronic control devices, stored-energy type of resistance welding machine, sheet metal work, and an interesting two-page picture story telling how induction brazing and unique press operations aided production of a bomb fuse seat liner. The Fred Goat Co. Inc., 314 E Dean St., Brooklyn, N. Y.

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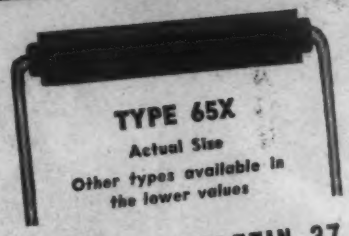

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RESISTOR BULLETIN 37 GIVES FULL DETAILS . . .

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They're Ideal for use in Aircraft and Naval Equipment . . .

because they retain their values and characteristics under extremes of temperature, humidity and climatic changes. Also because of their noiseless operation and exceptional durability.

STANDARD RANGE
1000 ohms to 10 megohms.

HIGH VALUES
15 megohms to 1,000,000 megohms.

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The S. S. White Dental Mfg. Co.
INDUSTRIAL DIVISION
Department R, 10 East 40th St., New York 16, N. Y.

"It's appendicitis!...rush a ski plane!"

*After Victory

SNOWBOUND *in a logging camp* . . . no doctor...no telephone...and a man's life in danger! Yet help is summoned instantly with a "walkie-talkie" radio... an instrument that is playing such a vital role on our battle fronts today, with scores of civilian uses in prospect after Victory.

And it is scientific products like these which will save lives, bring new comforts, conveniences and foster employment for everyone in the postwar reconstruction era.

The new skills and techniques we are continuously acquiring in our war production of precision parts have made it possible for us to develop *low cost* mass production methods in the making of the parts so necessary to the proper functioning of scientific instruments.

(*Below*) A few of the many thousands of our precision-made parts that are helping bring Victory closer, and which will help mould our world of tomorrow.

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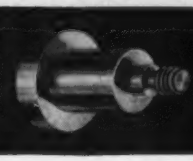
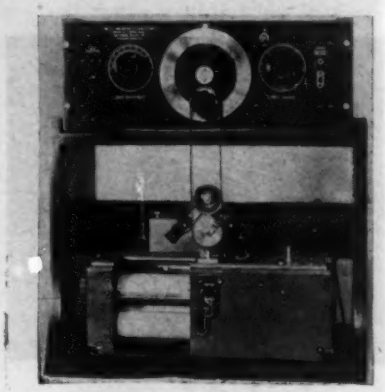


Automatic Frequency Response Recorder

AN AUTOMATIC FREQUENCY response recorder used in combination with General Radio's audio beat frequency oscillator is a measuring setup designed to serve as a labor-saving device, which may be used by unskilled help to perform a multiude of measurements of electro-acoustical apparatus. The recorder and oscillator



may also be used as separate units since the setup does not involve complicated connections. The recorder has an automatic frequency run ranging from 20 to 20,000 cycles and covers a range of either 20, 40 or 60 db. Recording (in ink on standard semi-log paper) may be made forwards or backwards. The recorder stops automatically at any pre-determined point of the frequency scale.

Sound Apparatus Company, 150 West 46th St., New York 19, N. Y.

Low-Loss Resistor Coil Coating

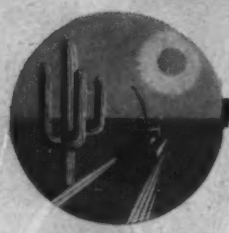
A NEW TYPE LOW-LOSS resistor coating marketed under the trade name of Lectraseel is a vitreous coating which is highly resistant to thermal shock. The manufacturer states its co-efficient of expansion and contraction, parallels that of ceramic cores now used and that weather tests indicate that coils coated with this coating will not corrode.

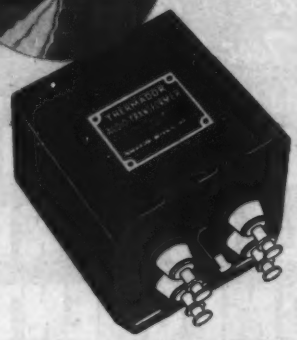
Pemco Corp., Baltimore, Md.

Literature

Engineering Bulletins. Complete data on grades and applications of Panelyte, a structural plastic, is available in binder form for filing and easy reference from Panelyte Division, St. Regis Paper Co., 230 Park Ave., New York, N. Y.

Defeats





THERMATITE TREATED

THERMADOR TRANSFORMERS

Thermador Transformers are Thermatite treated to withstand extreme temperatures and humidity—arid or moist heat—dry or damp cold do not hamper their efficiency. Thermatite is the name of a process of accurate heat controlled vacuum impregnation developed and improved over a period of ten years.

Thermador also manufactures built-in Electric Heaters, Electric Ranges, Electric Water Heaters.

Throat Microphone. Catalogue No. 961 presents data on U. S. Army Signal Corps throat microphone type T-30-S. Diagrams of the operational circuits and extension cord assemblies are included. Descriptive data is included on the functions of the instrument, complete description, wearing methods, resistance, microphone current, repairing, dimensions and component weights. A price list is also included. Catalogue No. 961 available from Universal Microphone Co., Inglewood, Calif.

Electronic Tubes. Technical data pertaining to various electronic power and transmitting tubes manufactured by Electronic Enterprises, Inc., is given in their latest booklet. The operation of mercury vapor rectifier tubes is given. Among those described in the booklet are type 866A/866 half-wave mercury-vapor rectifier, type 872-A half-wave mercury-vapor rectifier, type 575-A half-wave mercury-vapor rectifier, type 836 half-wave high-vacuum rectifier, type 371-B half-wave high-vacuum rectifier, type 8020 half-wave high-vacuum rectifier, type EE-200 power amplifier oscillator, class B modulator, and type 100-TH transmitting triode, tantalum anode. Booklet available from Electronic Enterprises, Inc., 65–67 Seventh Ave., Newark, N. J.

Radio Data Handbook. Allied's 48-page Radio Data Handbook, edited by Lieut. Nelson M. Cooke, is a condensed handbook of formulas, charts and data commonly used in the radio and electronics field. The handbook is divided into four parts: mathematical data, radio and electronic formulas, engineering and servicing information and a set of four-place log and trig tables. Formulas are given for decibels, resistance, capacitance, inductance, reactance, resonance, frequency, "Q" factor, impedance, conductance, susceptance, admittance, transients, peak, average and r.m.s. voltage and current values, meter shunts and multipliers, vacuum-tube constants. Radio color codes, interchangeable tubes, pilot lamps, plug-in-ballast resistors, and coil winding are covered in the data section. Copies of the "Radio Data Handbook" available from Allied Radio Corp., 833 W. Jackson Blvd., Chicago, Ill., for twenty-five cents.

Electronic Heating. The story of electronic heating for high-speed brazing, hardening, annealing and soldering is given in *Electric Heat*, third quarter, 1943 (a G-E publication). This issue contains other articles on electronic heating among which are "Heating Soft Metals," a major application of electric immersion heating; "Electric Heat Solves Wrapping Problem," telling how electric heat offered the solution to wrapping cheese since tin foil went to war. This issue, designated GES-3130-2, is available from General Electric Co., Schenectady, N. Y.

Bulletin GEA-4076 describes the electronic method of heating metals, and gives in detail the specifications of both the 5-kw and 15-kw, 550-kc electronic heaters. Parts which may be brazed, soldered, or surface hardened by electronic heating are included in this bulletin. Bulletin GEA-4076 available from General Electric Co., Schenectady, N. Y.

Rectifier Equipment. In a ten-page booklet Selectro-Plater, a rectifier unit, is described. Selectro-Platers are used for chromic acid anodizing and sulphuric acid anodizing of metals. This booklet available from Green Electric Sales Corp., 130 Cedar St., New York, 6, N. Y.

Timing Motors and Devices. Synchronous motor driven and electronic timing devices are covered in a twenty-four page catalog, No. 112, which also includes descriptions of many recent developments in the field of timing engineering. An outline of the principles used in timing motors, both a.c. and d.c., with views of the motor, brake unit, reset unit and friction device are given in the catalog. Also technical data on the full range of timing applications. Catalog No. 112 from Haydon Mfg. Co., Forestville, Conn.

Harmonics. "Identification of Harmonics in a Harmonic Series" is an article appearing in the September 1943 issue of *The General Radio Experimenter*. The article covers: using calibrated oscillator or receiver, using calibrated oscillator or receiver and successive harmonic series, identifying harmonics separated by a desired interval and identifying harmonics on uncalibrated equipment. Copies available from General Radio Co., 30 State St., Cambridge, 39, Mass.

Perforating Stamps

(*Continued from page* 125)

the roller carriage in the direction required to center the web. In this manner the web is delivered to the longitudinal or lengthwise perforating elements.

The longitudinal perforating elements consist of punch and die wheels producing twenty-two rows of perforations, eleven on each side of the center register marks. These punch and die wheels have provisions for manual adjustment for coarse calibration. For fine calibration there are two additional sets of scanning heads, one set on each side of the web, controlled by additional register means. These scanning heads operate in a manner similar to the web center scanning head, and each functions to operate a control for automatically adjusting the width between the rows of punchings to compensate for variation in the width of the paper brought about in the printing and gumming processes.

The web then proceeds to the lateral perforations, which are produced by cylinders having punch and die rows extending across the web. Registration of these perforations is controlled by impulses from two sources, one from register marks printed opposite each row of stamps on the web and the other from the light source transmitted through a slotted disk in synchronism with the punch and die cylinders. The cut-off knife is in synchronism with the perforating cylinders and shears off the sheets in direct relation to the position of the perforations. The scanning heads on the lateral registration marks and the cylinder registration disk operate a differential on the mechanism of the rollers controlling the feed of the web through the lateral perforators.

To sum up: the electronic control for the perforators consists of (1) means to center the web, (2) means to maintain the proper longitudinal perforations, and (3) means to maintain the proper lateral perforations and to shear into sheets. Each of these electronic controls has buttons at various points on the machine for manual control of the respective differential so that the operator may make a speedy correction of any extreme conditions.

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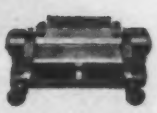

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Magnet Design

(Continued from page 131)

Running through the calculations for the circuit of Fig. 10, we find $R_1 = 2.0$ and $F = 5.2$. Consequently, $A_m = 5.2 \times 3500 \times 1.742/4300 = 7.37$ sq. cm. $= 1.143$ sq. in., and $l_m = 1.35 \times 3500 \times 0.3175/380 = 3.948$ cm. $= 1.554$ in. (as before).

These values of A_m and l_m are entirely consistent with the dimensions of Fig. 10, used to determine our value of F. Consequently, a third calculation is unnecessary and we may consider these values as the specifications for the required magnet.

The final circuit is shown in Fig. 11. It is to be borne in mind that this is for a magnet of Alnico II, and no other alloy. If the magnet size for Alnico III or a tungsten or cobalt-steel magnet is required (in order to study the economics of the situation, for instance) these calculations must be repeated, using in each case the B_s and H_s for the magnet alloy under study.

Incidentally, the magnet of Fig. 11 need not necessarily be 1.070 in. square as shown. It might, for instance, be 1.000 in. x 1.143 in. or any two dimensions which give a cross-section of 1.143 sq. in. and which do not cause the circuit to depart materially from the dimensions of Fig. 10.

Selecting Magnet Material

Just one more problem: Suppose the above-mentioned instrument manufacturer, because of a sudden shift in demand just as his new instrument is starting through production, decides that perhaps he ought to reduce the flux density in the gap of this instrument from 3500 gauss to 3200, or possibly even to 3000 gauss. Assume that all the parts for the original design have been purchased or manufactured and assembly work has been started.

Obviously, it would involve a severe loss to redesign at this point and scrap all finished parts. So the manufacturer might wonder if it wouldn't be more economical in the long run to scrap his stock of Alnico II magnets and to replace it with magnets of the same size but of smaller energy content.

The problem, then, is to take the

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circuit of Fig. 11 exactly as it stands and determine what alloy or alloys, if any, may be used to replace the Alnico II magnet and give the desired results.

The nomograph of Fig. 8 is most helpful in this type of problem. Using the values we determined earlier ($l_g = 0.3175$ cm.; $A_g = 1.742$ sq. cm.; $l_m = 3.948$ cm.; $A_m = 7.37$ sq. cm.; $F = 5.2$; $f = 1.35$), we get:

$$f\, l_g/l_m = 1.35 \times 0.3175/3.948 = 0.109$$
$$F\, A_g/A_m = 5.2 \times 1.742/7.37 = 1.23$$

Marking these two points off on the appropriate scales, i.e., the X' and the Y scales, respectively, and laying a straight-edge between these points and the point 3200 on the B_g scale, we arrive at the values 340 and 3900 on the H_m and B_m scales, respectively.

Now, erect a perpendicular to the H_m scale at 340 and another perpendicular to the B_m scale at 3900. These two lines intersect at a point which is just inside the demagnetization curve for Alnico III, indicating that if Alnico III is used as the alloy for the permanent magnet in question the flux density in the air gap will just slightly exceed 3200 gauss. Alnico III will therefore satisfactorily fulfill the conditions stipulated.

Since the intersection of these perpendiculars lies outside the curve for Nipermag B, this alloy would give less than 3200 gauss in the gap and hence would be unsatisfactory.

Repeat the above process using the point 3000 on the B_g scale. This gives us values of 325 on the H_m scale and 3700 on the B_m scale. The intersection of the perpendiculars at these points occurs inside the Nipermag B curve. Hence, Nipermag B is a satisfactory alloy to produce 3000 gauss in the air gap. Alnico III may also be used to produce 3000 gauss but would require more demagnetization than Nipermag B. Neither of these alloys would be working at its B_o, H_o point under the conditions of this problem. This is to be expected since the circuit was designed to make Alnico II operate at its maximum efficiency.

Figure 8 makes an excellent summary of this initial paper on the subject of permanent magnet design. It shows graphically that no one of the alloys under consideration would give a higher flux density than any of the others in all types of gaps.

If both gap and magnet size are

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fixed, it should be readily apparent that for certain relationships of these factors, both Nipermag B and Alnico II are sometimes better even than Alnico V. Nipermag B, cutting as it does all the Alnico curves shown, changes (for low values of H_m) from the alloy producing the lowest flux density in a gap to (for high values of H_m) the alloy producing the highest flux density in a gap.

APPENDIX

Refresher Course in Magnetism

WHEN PEOPLE FIRST became interested in electric and magnetic phenomena, their interests tended to center in the most obvious manifestations of each. Since the physical force between two lodestones was most apparent it was quite natural that people should set up their definitions with this as a basis. Disliking the concept of a force "acting at a distance," they invented a medium for the transmission of this force, and explained that it was through "stresses" set up in this medium that the force was transmitted.

Flux Lines ϕ. To better enable themselves to picture results, they drew lines between two magnetized bodies, the direction of a line at any given point representing the direction of the stress at that point and the density of lines passing through an infinitesimally small area surrounding a point representing the magnitude, normal to the area chosen, of the stress at that point. These lines are known as "lines of force", "flux lines", or "maxwells", and are designated by the Greek letter ϕ.

Unit North Pole. In order to assign values to the intensity of the stress exerted between two magnetized bodies, early magnetics engineers introduced the concept of the unit North pole; i.e., a North pole of unit magnetic strength completely divorced of any associated South pole, and in their imagination placed this unit N pole in the stressed medium (usually called "magnetic field") and again in their imaginations observed the force exerted on this N pole.

Field Strength H. Now by a combination of concepts, these people were able to take the force acting upon the unit N pole as a result of any combination of magnets, divorce it entirely of its source and assign it as a property of the space (under

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the conditions stipulated) in which the N pole stood. Thus the field stresses were given numerical values and directions, and it is, in fact, in this way that field strength is defined. A field is said to possess a strength of one oersted at a given point, if it exerts upon a unit magnetic pole placed at this point, a force of one dyne. Field strength is usually designated by *H*.

Oersted. It was mentioned above that the convention decided upon for the *representation* of strength of a field at a given point was by the number of lines per unit area at that point. It was hence necessary to relate this convention to the above definition of the strength of a field. It was decided to represent a field of one oersted strength by one line per square centimeter, 57 oersteds by 57 lines per square centimeter, etc. This is not a re-definition of the term but is rather an agreement upon how this quantity is to be represented and thought of in practice.

An Experiment. Let us perform the following simple experiment: (a) Take a small piece of brass and bring it up slowly to either pole of a charged horseshoe magnet. Nothing happens. (b) Repeat with a small piece of iron. We note a definite force on the iron as it gets close to the magnet. (c) Demagnetize the magnet and repeat (a) and (b). Nothing happens. (d) Place a small search coil of several turns connected to a ballistic galvanometer* about the small pieces of brass and iron, and withdraw the coil from the pieces while they are in the field of the magnet. We detect a much greater deflection of the galvanometer when the coil is withdrawn from the iron than when it is withdrawn from the brass piece. (e) Repeat (d) but with the pieces of brass and iron not under the influence of the magnet. The galvanometer fails to deflect in either case.

Magnetic Induction B. From the above we see that something happens to a piece of iron when in the presence of a magnetic field, something which does happen to a piece of brass. We call this "something" the phenomenon of "magnetic induction". This phenomenon is extremely complicated but for our purposes we may

* A ballistic galvanometer is an instrument which can be used to measure numbers of flux lines, and will be described in a later article of this series.

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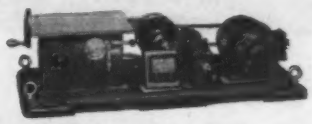

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content ourselves with the understanding that when a piece of iron is placed under the influence of a magnetic field, it develops within itself many more lines of force than may be accounted for by the strength of the energizing field itself. Magnetic induction is usually designated by B and the unit of measurement of this quantity is known as the gauss, which may be defined well enough for our purpose as one line of induction per square centimeter.

Basic Equations. From the definitions, we may state:

$$\phi = \int H \cos (H, dA)\, dA \qquad (1)$$

If the field is uniform over the area A in question (i.e., its magnitude and direction are constant at each point in this area) Eq. (1) becomes:

$$\phi = HA \qquad (2)$$

Similarly, we may write:

$$\phi = \int B \cos (B, dA)\, dA \qquad (3)$$

and also if the flux density is uniform over the area A:

$$\phi = BA \qquad (4)$$

Relations Between B, ψ and H. Let us perform another simple experiment with the piece of iron, search coil and ballistic galvanometer previously used. Place the search coil around the center of the piece of iron and with the iron in any predetermined relationship to the magnet, determine the galvanometer deflection: (a) by removal of the search coil from the iron; (b) with the search coil back in its original position, by removal of the iron from the search coil; (c) with the iron removed but with the search coil still in its original position, by removal of the search coil. The first deflection will be proportional to B, the flux density in the iron. The second deflection will be in proportion to the intrinsic magnetic induction in the iron itself. Let us designate this by the symbol ψ. The third deflection will be proportional to H. Hence, our galvanometer tells us that the following is true:

$$B = H + \psi \qquad (5)$$

This is a vector equation, and directions as well as magnitudes must be considered when adding.

Hysteresis Loop. A long time ago, magnetics engineers found the necessity of determining the exact relationship between B and H for any given piece of iron. Consequently, they took a ballistic galvanometer and rigged up an apparatus to deter-

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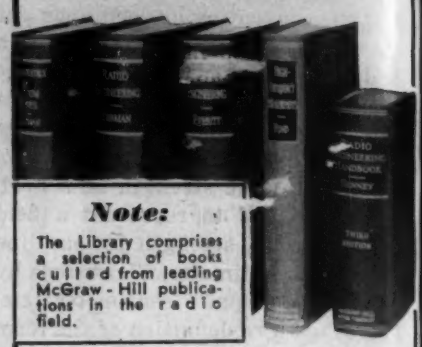

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mine this relationship. The results look something like that shown in Fig. 1 (a) of the text.

Suppose a specimen initially demagnetized and applying a magnetic field H the induction B was forced to increase with H along the line known as the normal magnetization curve. The iron saturates at the point at which the normal magnetization curve becomes a straight line. This, of course, is due to the fact that all the molecular magnets have been lined up in the direction of the field. Consequently, ψ is unable to increase further and B becomes a straight-line function of H. As H is decreased, B does not retrace its steps but instead travels the path aB_r. When H is reversed, B follows the path B_rH_cb. The loop closes itself in a reversed image of the first half. The complete loop is known as the "major hysteresis loop" of the particular piece of iron or magnet under test.

Demagnetization Curve. Referring again to Fig. 1 (a) of the text, it will be noted that we have segregated that portion of the major hysteresis loop appearing in the second quadrant and reproduced it in Fig. 1 (b). This section of the loop is known as the "demagnetization curve".

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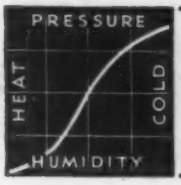

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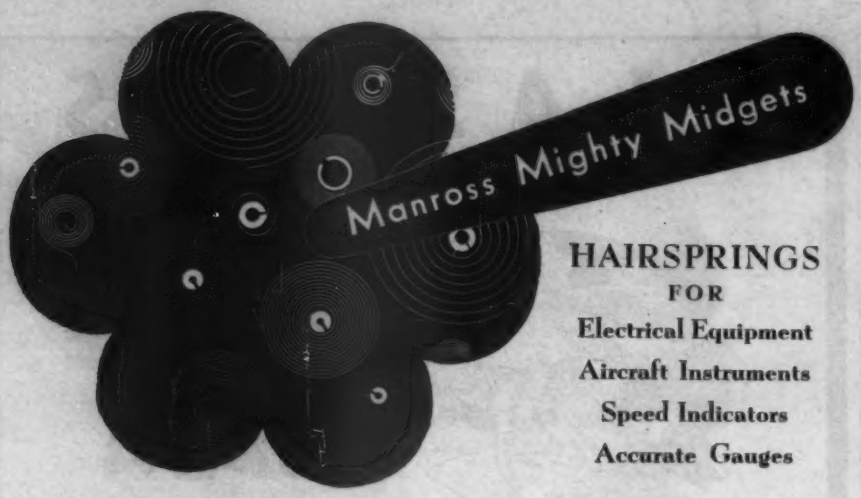

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VAPLEY

Electronic Generator

(*Continued from page* 134)

at the rate determined by the time constant of R_1 and C. If switch SW is now closed, an exponentially rising current will be obtained in the output of the amplifier, the polarity of the current being determined by the polarity of the connection across the input terminals. After the current reaches a stationary value, switch SW_1 may be opened, permitting C to discharge through R_2.

The detailed diagram of the chronaxie measuring equipment is shown in Fig. 4. The battery is shunted by a 5000-ohm potentiometer to allow arbitrary selection of current amplitudes for the chronaxie measurement. The time constant both for decreasing or increasing currents can be adjusted by changing the values of C, R_1 and R_2. Four-pole, double-throw switch SW_2 (shown in two parts for clarity) allows the battery to be used as the driving source for chronaxie measurements or as a variable-amplitude, reversible-polarity d-c source for the amplifier.

The surging rheostat used for changing the screen grid voltage of the amplifier output tubes can be switched over to perform a similar function for surging the d-c output with switch SW_4 being provided for this purpose. The motor-driven surging rheostat forms a bridge circuit together with two 1250-ohm resistors. With the slider of the surge rheostat in the center position the bridge is balanced and no voltage appears across the amplifier input terminals. Depending on the position of the rotating arm the potential across the input varies between a positive and a negative extreme yielding an alternating current of very low frequency (as low as 0.2 cps) determined by the speed of the driving motor. The speed of the motor is variable in a wide range. One arm of the fixed ratio bridge is shunted by switch SW_3, allowing the short-circuiting of one of the 1250-ohm resistors. If this is done, the polarity of the surging current does not change but the amplitude varies between a maximum and minimum.

BIBLIOGRAPHY

Trevino, S. N. and Offner, F., An A-C Operated D-C Amplifier, *Rev. Sci. Instr.*, No. 12, p. 412, Dec. 1940.

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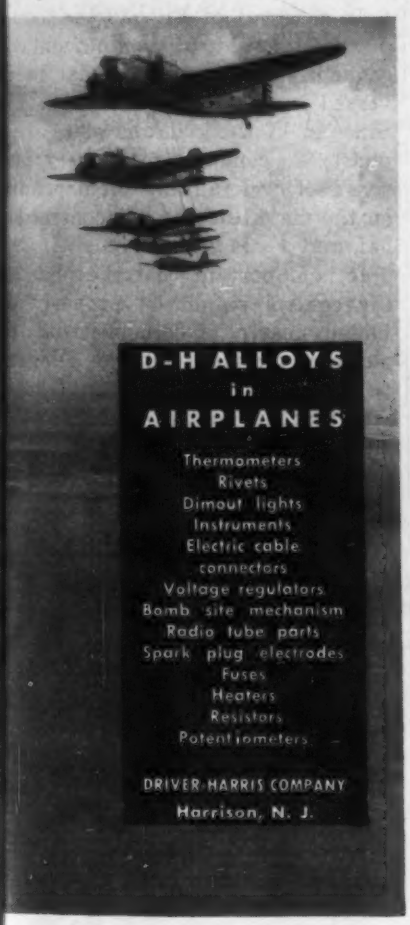

Volume Compressor

(*Continued from page* 135)

connection between the crossed wires at P. (Actually there is still 0.5 meg between the wires due to R_1 and R_2, but this can be considered infinitely high for purposes of explanation.) Now the polarity of the two secondaries of the transformer is such that they oppose each other and provide the desired suppression on signal peaks.

Adjustment Procedure

Initial adjustment involves setting the input potentiometer to zero, feeding in an audio signal tone of a strength such as to give a compressor output of 9½ vu, then advancing the potentiometer until the output drops to 8 vu. This sets the threshold at which effective compression begins. A compression ratio of 10 to 1 will then be provided on strong peaks, meaning that a 10 db increase in input level will be limited to a 1 db increase in output level.

The circuit requires no critical voltages, hence the simple and conventional 6 × 5 rectifier circuit is entirely adequate as a power supply. It has extremely low inherent distortion, with phase shift distortions not even noticeable on an oscilloscope and with a frequency response that is flat within 1.5 db over the entire range from 40 to 14,000 cycles. Tube failures or other defects in the compressor cannot interrupt the program; in fact, when a compressor tube is pulled out, the level automatically drops about 5 db to protect the transmitter against peaks.

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Direction Finders—Part II

(*Continued from page* 146)

tion. If E is added vectorially to E_p for V_{10}, the resultant grid voltage E_g is seen to be advanced in phase with respect to E_p, and V_{10} conducts over a greater portion of each positive half cycle than it did on the standby a-c bias condition. Conversely, E_p for V_{11} is further retarded and the current reduced. As the loop is displaced farther from the null so that the control signal E increases in magnitude, the resultant E_g for V_{11} swings nearly in phase with the plate voltage. The plate current then increases to a maximum. The voltage E_g for V_{11} becomes nearly in phase opposition to its plate, and the corresponding plate current diminishes.

Actually, automatic overload control on the loop amplifier and modulator tubes limits the maximum value of E so that it does not increase much beyond the value required for optimum control. The signal E rises rapidly to give full motor torque near the null and then flattens off for larger displacements.

In case (*c*) of Fig. 18 the loop is on the other side of the null, and consequently the control signal is reversed in phase compared with (*b*). Since in V_{11} the grid and plate are in phase, V_{11} conducts over every positive half cycle an amount depending on the magnitude of the control signal, and V_{10} is cut off.

It is important that the phase of the control signal be properly adjusted nearly to coincide with the phase of the plate voltage. Diagram (*d*) shows conditions as in (*c*), except that the control signal is badly misphased so that it lags the plate of V_{11}. The only effect on V_{11} is to reduce its plate current slightly, but the resultant grid voltage on V_{10} now leads the plate voltage, and instead of being cut off this tube is nearly full on. Such a condition results in erratic operation and the motor may stall.

Anti-Hunt Circuit. Generator M_3 is mounted on the same shaft as motor M_2, as will be seen in the view of the loop unit in Fig. 15. The generator develops a 100-cycle voltage of reversing phase and of varying amplitude, depending upon direction and speed of rotation respectively. It consists of a two-pole exciting wind-

ing W_s, two-pole output winding W_o, and an iron rotor which has a copper shell over it. At standstill the 100-cycle alternating flux due to W_s does not couple with the output winding. When rotation occurs, eddy currents in the copper shell distort the flux and couple it to W_o, thus producing output voltage. This may be referred to as armature reaction. The magnitude of this voltage is proportional to the speed, and it reverses in phase with reversal of rotation.

This anti-hunt voltage is fed through R_{20} into the 100-cycle filter at the input of control amplifier V_9, and is superimposed on the 100-cycle control signal. It is phased to be always in direct opposition to the control signal when the loop is off the null and driving toward it. The signal overrides the small bucking anti-hunt voltage until within about two degrees of the null position, when the signal and generator voltages are about of equal magnitude at full motor speed, resulting in zero control signal input to V_9.

At this point the reversed-phase generator voltage overrides the diminishing loop signal and fires the reverse thyratron to slow the motor. Due to the phase shift control of the thyratrons, the braking action is proportional to the excess of anti-hunt signal over loop signal. As the motor slows down, the anti-hunt voltage diminishes, and the control signal continues to drive the motor, so that the loop comes to rest on the null. The anti-hunt voltage constitutes a form of dynamic braking that is far superior to a friction brake system in securing accurate follow-up operation with freedom from oscillation.*

Loop Overload Control. The control signal from the output of the second section of V_9 is fed back to V_{11}, where it is rectified by the diodes and used to develop a direct voltage across resistor R_{35}. This serves to bias the three tubes V_1, V_2, and V_3 of the loop amplifier to reduce their gain and hence to limit the increase in control signal from V_9 as the loop departs from the null point. This, in turn, makes the balance between loop and antenna pickup much less critical, while allowing full motor torque near the null point of the loop. C_{21}, R_4 and C_{20} constitute a filter to prevent feeding of control signal back to grids of loop channel tubes.

* Hazen, H. L., Theory of Servo Mechanisms, *Jrl. Franklin Inst.* 218, p. 279, Sept. 1934.

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Impulse Generator

(*Continued from page* 139)

ultimate voltage on the bus bar is always less than that theoretically produced at the top of the impulse generator.

The charge on the impulse generator is in fact divided, when the discharge occurs across the discharge gap, between the capacity of the impulse generator itself and the added capacity of the bus bar. The ratio between the voltage on the bus bar and the instantaneous voltage theoretically on the impulse generator just before the discharge gap breaks down is, therefore,

$$\frac{V_2}{V_1} = \frac{1}{1 + C_2/C_1}$$

where C_2 is the capacity of the bus bar and the top of the apparatus, and C_1 is the capacity of the impulse generator. A ratio of about 80 percent for V_2/V_1 was found in practice.

In accordance with the theory of oscillatory circuits, if the discharge is to be nonoscillatory (as it must be for the purpose in hand), it is necessary that the resistance in the discharge circuit should be such that $R^2 > 4L/C$. Hence the use of the damping resistance R_3 in Fig. 6.

Further Details

The spark gaps consist of 2-inch brass balls; the gaps should all be equal in length except the bottom one. This gap should theoretically be slightly shorter than the others, in order to initiate the discharge. It was found that the pulses did not occur regularly unless the ionized air produced by each spark was blown away from the gaps. A jet of air, at a few pounds per square inch pressure, was applied by means of glass tubes to each spark gap. About a

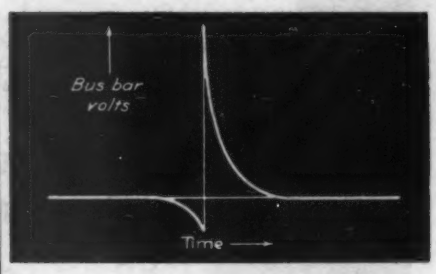

FIG. 7—Oscillogram showing the wave form of each pulse produced by the impulse generator

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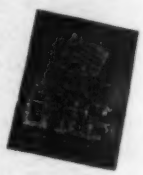

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The charging and grounding reistances on the impulse generator re each of 50-watt rating and of the wire-wound vitreous type. The harging resistance R_c is also of this ype, and consists of five 50-watt nits in series. The damping resisance R_s has a rating of 100 watts. The resistance load consists of four 0-watt resistances in series.

The charging voltage of the impulse generator was measured by connecting a voltmeter across the harging unit and observing the value of the voltage just before the gaps break down.

It will be observed that the valve nder test is operated "upside down", that is, with the anode grounded. This is the only way in which the current to a number of different electrodes can satisfactorily be measured. The cathode is heated by storage batteries supported on ¼-in. thick plate glass sheets.

The voltage applied to the horizontal plates of the oscilloscope is provided by means of capacity attenuators A or B. Top condensers C_1 and C_2 of both attenuators consist of two 4-in. copper balls separated about 5 cm. (This distance is sufficient to avoid breakdown at voltages up to more than 100 kv.) Bottom capacities C_3 and C_4 consist of a bank of mica condensers of various values from 0.00005 to 0.01 μf, and, in the case of attenuator B, a variable air dielectric condenser of 0.0005 μf capacity for fine adjustment. Any values of capacity within the range can be selected by means of shorting strips. R_1 and R_2 each consist of five 5-megohm 2-watt carbon resistors connected end to end in a Pyrex glass tube. Resistance R_3 has a maximum value of 100,000 ohms. If $C_1R_1 = C_2R_2$, and $C_3R_3 = C_4R_4$, there will be no phase or frequency dis-

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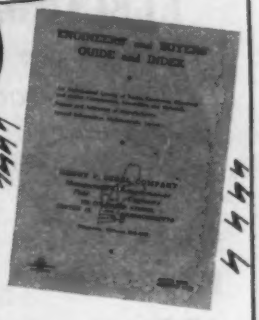

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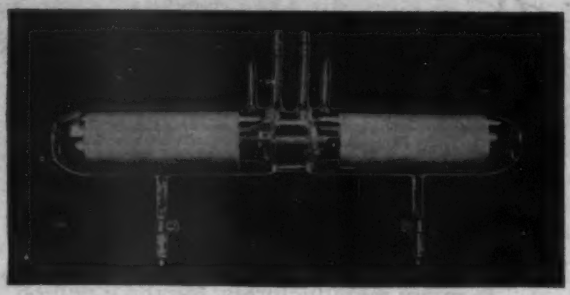

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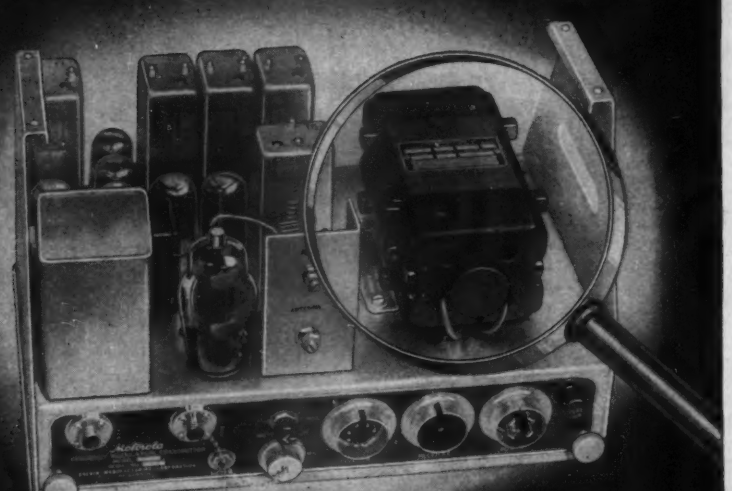

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tortion due to the attenuators. The frequency characteristic of the attenuators was measured from 30 cps to 1 Mc.

It will be observed in Fig. 6 that no amplifiers or volume control potentiometers are used between the oscilloscope deflection plates and the source of voltage. Any phase or amplitude distortion will produce distortion in the shape of the characteristic recorded on the oscilloscope. The wave front of the pulse is so steep and covers such a wide band of component frequencies that amplifiers would, if used, have to possess characteristics which would involve a program of development work.

Tests for phase distortion were made by applying the potentials from one attenuator simultaneously to the x and y deflection plates of the oscilloscope. A straight line results if phase distortion is negligible. It became clear, among other things, that even ordinary "good" amplifiers produced far too much phase distortion. Even the addition, for instance, of a simple volume control potentiometer was sufficient, when used at less than full gain, to produce a serious departure from the straight line which should have appeared on the screen.

An Experiment That Failed

It may be of some value, in giving prospective workers with this apparatus an idea of the peculiar properties of these very short-duration pulses, to describe an experiment which failed.

An attempt was made to operate the valve under test with the filament grounded so that a motor generator might be employed to heat the filament. Since the currents to several anodes might have to be measured, and the values of this cathode current itself did not give sufficient information alone, it was necessary to connect resistances between the anodes and the bus bar. The problem then arose of transferring the voltages across these to the y deflection plates of the oscilloscope. This circuit is illustrated in Fig. 8.

The idea occurred of causing the voltage across either R_1 or R_2 to supply the anode potential of an r-f oscillator positioned on the bus bar. The r-f output could be picked up by an inductively-coupled tuned circuit, rectified and applied to the y terminals of the oscilloscope. This oscillator was expected to give a linear

relationship between its r-f output and any current flowing through R_1 or R_2 and through the oscillator valve in parallel. By suitably choosing the time constants of the resistances and capacities involved, no appreciable phase distortion should be obtained.

The necessary transmitter and detector was easily provided, and, on bench tests with direct current gave the linear relationship required. In fact, as a sort of remote control d-c ammeter, the whole device was very successful. On setting up the oscillator and resistance on the bus bar, however, it was found that practically the whole of the impulse voltage (in this particular experiment, about 60 kv) was developed across them, although the value of the resistance was only 2000 ohms, and it was in series, at the time, with a main load resistance of 100,000 ohms connected in place of the valve shown under test in Fig. 8.

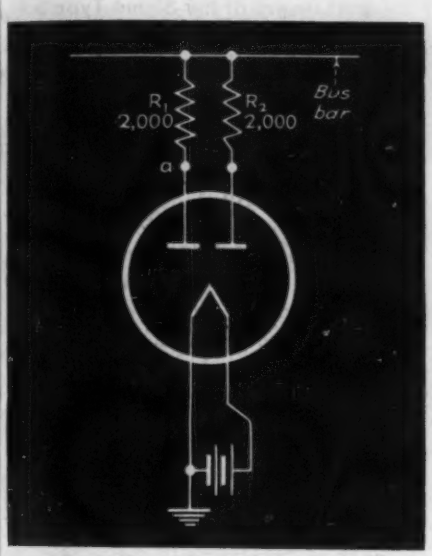

FIG. 8—Circuit which proved unsuccessful for testing high-power tubes

It was then realized that the effect was due to the relative time constants of the 100,000-ohm resistance and its parallel residual capacity and that of the 2000-ohm resistance with the valve impedance in parallel with it. The time constant of the latter combination is shorter than the former, and therefore point a in Fig. 8 remains at ground potential for an appreciable portion of the pulse time. The pulse has such an extremely sharp wave form that it reaches its maximum long before point a rises much above earth potential. Therefore, no matter how low the "ammeter" resistance R_1 may be in comparison with the 100,000-ohm load resistance, almost the full voltage of the impulse generator will be produced across the "ammeter".

This effect can be eradicated by properly balancing the two residual capacities concerned so as to produce an ordinary balanced RC attenuator. Unfortunately, however, no valve can possibly be balanced at all the component frequencies of the pulse, because it does not have a linear characteristic, and its characteristic varies with the value of the space current used.

Calibration of the Apparatus

Attention is drawn to the provision of the standard resistance-capacity attenuator A in Fig. 6, which is adjusted to have a flat frequency characteristic from 30 cps to 1 Mc. The deflection of the oscilloscope beam by the voltage from this standard attenuator is calibrated in terms of the peak voltage on the bus bar. Calibration is performed, and checked at intervals, by means of the adjustable spark gap shown in Fig. 6.

The other attenuator, B, is provided with a variable condenser C_2 and a variable resistance R_2 in the bottom arm. C_2 may be adjusted to produce any particular amplitude, and R_2 to produce the correct phase of the pulse voltage on the oscillograph over a considerable range.

In practice the procedure is first to apply the voltage from attenuator A to the oscilloscope, and to measure it. The outputs from A and that from the adjustable attenuator B are next applied respectively to the x and y plates of the oscilloscope. The condenser and resistances of the bottom section of attenuator B are then adjusted until a straight-line trace is produced. This indicates that attenuator B has a negligible phase error. During this process, the amplitude of the oscilloscope sweep caused by the voltage from B may also be adjusted by means of C_2 and R_2 to a convenient point on a calibrated scale in front of the oscilloscope screen.

Under working conditions, the standard attenuator is not used, and the voltage from the current-measuring resistances R_7 and R_8 are applied to both sets of y deflection plates as shown in Fig. 6. The oscilloscope is calibrated for anode currents by passing a known current through R_7 and R_8 and adjusting the value of

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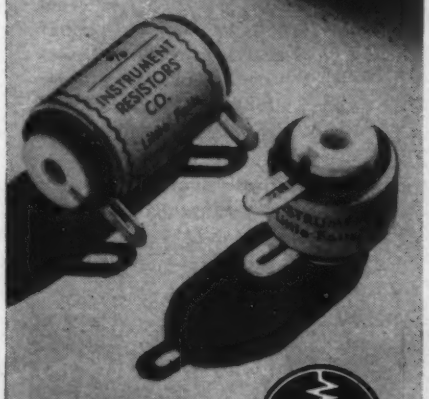

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The author desires to acknowledge much useful information about impulse generators in general which has been supplied by Mr. R. Davis, Mr. W. G. Standring, and Mr. G. W. Bowdler of the National Physical Laboratory. Acknowledgement is also due to Messrs. Rediffusion Ltd., for permission to publish the information herein.

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by GLENN JAMES, *Associate Professor of Mathematics, University of California, assisted by* ROBERT C. JAMES, *teaching fellow, California Institute of Technology. The Digest Press, Van Nuys, California, Revised Edition, 1943, 319 pages, price $3.00.*

BASIC MATHMETICAL WORDS and phrases from arithmetic through the calculus are defined in detail appropriate to the mathematical maturity of those likely to be looking up a particular term. Thus, terms likely to be found in high school books are defined in language geared to the high school level, while terms like Fourier's series contain the formulas and related data that might be needed by an electrical engineering graduate or design engineer. Many of the basic terms beyond calculus are also included.

The book is essentially a dual work in that it contains a great many terms related to the mathematics of business, such as insurance and stock market terms, but these in no way detract from its usefulness to the engineer.

For one seeking to refresh the memory on mathematical concepts without wading through a collection of books, this dictionary can save a great deal of time. It constitutes also a real contribution toward evolutionary standardization of mathematical terms.

For a bit of mathematical human interest, terms like casting out nines, four-color problem, nim, Pascal's triangle and pentagram are worth looking up. The electronic engineer would probably want to know more about photoelectric number sieve than the brief definition "A mechanical device for factoring large numbers", but in general the definitions are satisfactorily complete for all usages of the mathematical terms.

The appendix will be found particularly valuable for its five-place table of common logarithms, four-place table of trig functions and their logarithms, a table of 423 integrals and a highly complete collection of the symbols used in arithmetic and algebra, trigonometry, geometry, calculus and finance.—J.M.

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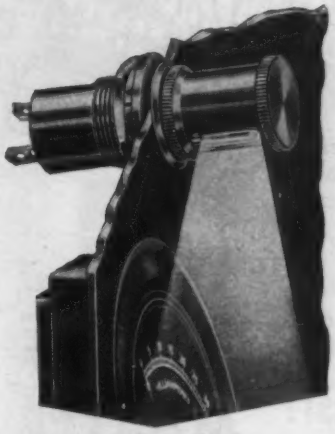

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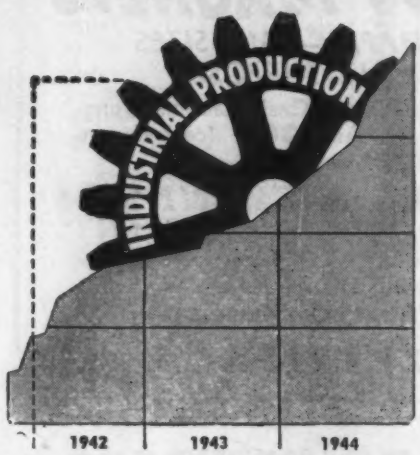

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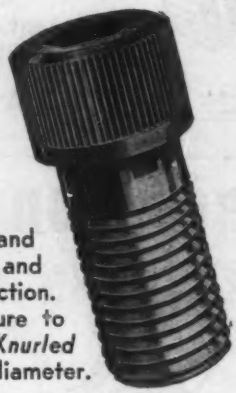

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By AMERICAN SOCIETY FOR TESTING MATERIALS, *Philadelphia, 256 pages, $4.*

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This A.S.T.M. volume will be found a convenient guide and reference work for any who are engaged in industrial radiographic operations. The volume contains quite a number of tables, graphs, and diagrams illustrating recommended practices and photographs of x-ray equipment for reproduction of radiographs themselves.—B.D.

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Reference Data for Radio Engineers

Edited by H. T. KOHLHAAS, *Editor of Electrical Communication. Federal Telephone and Radio Corp. (an I. T. & T. Associate), 67 Broad St., New York, 200 pages, price $1.00 ($.75 per copy in lots of 12 or more).*

BY BRIDGING THE GAP between the handbook and the standard radio engineering texts and at the same time providing a wealth of often-used radio reference data from each, along with new highly practical tube, circuit, transmission line and filter data for the technician, this book earns for itself a prominent place in every radio and electronic engineer's library. Considerable of its contents has heretofore appeared only in magazines, little-known books or government publications, but the real value lies in the logical selection and orderly arrangement of the material.

This volume is outstanding in its inclusion of data and material specifically selected for everyday use by a wide variety of American engineers. Of particular value is the 9-page section on wave guides and resonators, coordinating formulas, charts and tables that heretofore have been scattered throughout the recent literature.—J.M.

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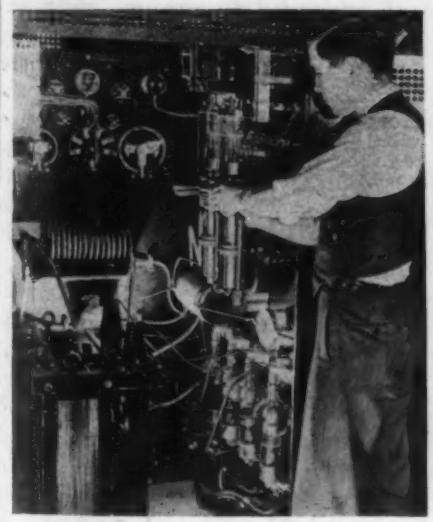

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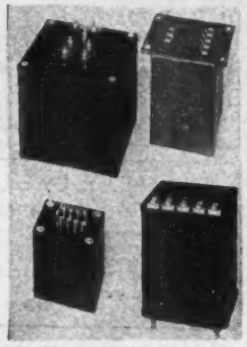

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Experiments in Electronics and Communication Engineering

By E. H. SCHULZ and L. T. ANDERSON, *Illinois Institute of Technology, 381 p., price $3, Harper & Bros., New York.*

IT IS BELIEVED that the authors have adequately expressed the purpose and scope of their volume in the preface which, in part, reads as follows: "This book is intended to serve as a laboratory text for courses at college level in electronics, communication networks, radio, and ultrahigh frequency phenomena. In addition, sufficient experiments in basic d-c and a-c circuits necessary for these courses are included in chapters 3 and 4. An attempt was made to organize the material in such a way that it would be adaptable to the Army-Navy College Training Program and to other accelerated War Training Programs. Sufficient information is given to make it possible for a student to do the various tests with a minimum of verbal instruction, but at the same time the "cook book" style has been carefully avoided.

The text includes 108 experiments ranging from simple direct current measurements to complete video amplifiers, radio receivers, radio transmitters, and antenna systems, microwave equipment, and so on. The material is divided into chapters according to subject matter. Each experiment consists of a brief discussion of the principles involved, the procedure to be followed, and a list of suggested apparatus. Each experiment is made as complete as possible. If desired, certain parts of the experiment may be selected in accordance with the laboratory time available or the point that the instructor wishes to stress. Experiments covering a wider field may be obtained by combining sections of several experiments.

The first chapter deals with laboratory technique, the purpose of laboratory work, preparations for laboratory experimental work, protection of apparatus, keeping notes and recorded data, curve plotting and similar pertinent data which should be required of any experimental worker before he ever sets foot into a laboratory. In a similar vein, chapter 2 deals with laboratory equipment which introduces the student to the essential characteristics of cir-

cuit elements, measuring instruments, and the rating and limitations of certain types of laboratory equipment. In themselves, these two chapters are a reasonable safeguard that laboratory equipment will not be too frequently or too seriously mishandled. Chapters 3 and 4 deal with experiments on the measurement of d-c circuits and a-c circuits, respectively. Subsequent chapters deal with network theories and four-terminal networks, electron tubes, cathode-ray tubes and circuits, power supplies, amplifiers, oscillators, modulation and detection, radio receivers, radio transmitters, and finally, transmission lines, wave guides and radiation. The chapters are, with good justification, of unequal length. There are 20 experiments in the chapter on alternating current circuits and only four experiments on power supplies. As is customary with laboratory manuals, the theory and mathematical development is frequently omitted although the pertinent equations for an experiment are included where necessary. References are given at the end of each chapter for the student who requires further treatment than can be given in a laboratory manual.

In general, the experiments seem to be very well selected and adequately presented. The drawings and type are distinct and clear although the pages have been reproduced from a typed manuscript rather than being printed from set type, and a number of photographic reproductions are badly executed.—B.D.

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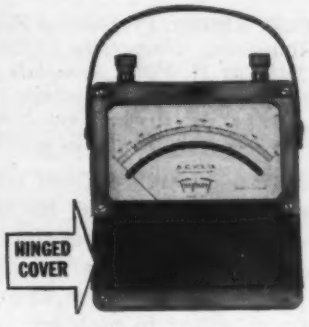

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Mathematics Essential to Electricity and Radio

By NELSON M. COOKE, *Lieutenant, U. S. Navy, and* JOSEPH B. ORLEANS, *Head of Department of Mathematics, George Washington High School, New York. McGraw-Hill Book Co., Inc., New York, 1943, 418 pages, price $3.00.*

AN EXCELLENT ADAPTATION of Lt. Cooke's technical best-seller, "Mathematics for Electricians and Radiomen." It is now suitable for the secondary-school level and for high-school teaching techniques. From addition and subtraction of negative numbers, the book takes the student efficiently and thoroughly through algebraic operations, equations, powers of ten, Ohm's Law and its practical applications, uses for graphs, exponents and radicals, quadratic equations, Kirchhoff's Laws, logarithms and their practical uses, trigonometry applying to radio, fundamental ideas of alternating currents, series and parallel circuits, and a particularly effective and simple treatment of both rectangular and polar forms of notation for a-c circuits.

All the features of the parent book are retained, including presentation of rules in italics for ready reference, frequent groupings of practical radio and electrical problems, with answers at the back of the book, and handy tables of logarithms and trig functions in the appendix. Logical organization and careful indexing give this simplified version a reference value to the engineer seeking merely to refresh his memory regarding some one particular fundamental mathematical operation.—J.M.

• • •

Introduction to Circuit Analysis

By ABNER R. KNIGHT, *Profesor of Electrical Engineering, University of Illinois, and* GILBERT H. FETT, *Associate in Electrical Engineering, University of Illinois. Harper & Bros., New York, 1944, 447 pages, price $4.00.*

A REFRESHING departure from conventional textbooks intended for the basic course in electrical engineering, having as its goal the development of the ability to analyze, choose and create solutions to problems rather than to merely substitute numbers in formulas and solve for the answer. In fact, the authors warn in their preface that some of their problems do not have any "right" answer, being included to give the better student a chance to develop ingenuity in searching for the most reasonable solution. No answers for problems appear in the book.

Another departure from convention is a treatment of all circuits as units, instead of placing d-c, magnetic and a-c circuits in separate courses. Basic laws are generalized to make them apply to magnetostatics and electrostatics as well as to electrodynamics.

Emphasis is placed on understanding the physics of a problem rather than upon detailed methods applying to special cases. This permits extending the scope of the book in the final chapter to generalized attacks on problems involving irregular periodic waves, using Fourier series. Several methods of determining the coefficients are presented.

The chapter on electrostatic circuits is deserving of special mention for its treatment of equipotential lines, a subject of increasingly greater importance in electronics. —J.M.

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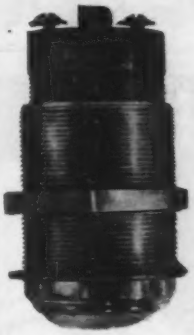

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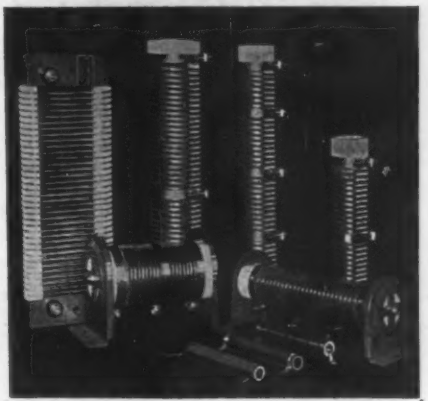

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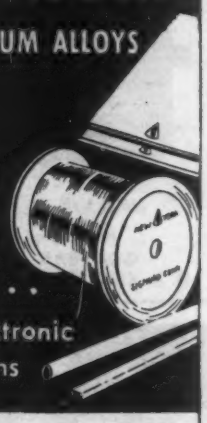

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BACK TALK

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment on articles which have been published in Electronics

Bimorph

WE NOTE in the September issue of ELECTRONICS, at page 165, an article entitled "Hearing Aid Circuits".

The article deals with methods of connecting a Brush rochelle salt earphone unit to the output stage of a hearing aid amplifier, and utilizes the word "Bimorph".

This letter is to inform you that the word "Bimorph" is a Trade Mark registered by The Brush Development Company in the United States Patent Office, Certificate No. 386,307, and as such should be capitalized and bear a notation to the effect that it is a trade mark of The Brush Development Company.

We note in your magazine several excellent examples of trade mark notices, such, for example, as Pyranol on Page 19, Mycalex on Page 23, and Pyrex on Page 73.

EBER J. HYDE,
Patent Dept.
Brush Development Co.
Cleveland, Ohio

Memory Machine

WITH REFERENCE to your article "Improvised Memorizing Machine" on page 156-157 of the September issue of ELECTRONICS, might I suggest the use of a magnetic tape instead of the d-c motors described in that article. The output from the ignitron could be fed into the magnetizing element of the tape, and the memorizing time could be made as long as desired by making the tape of the desired length. This would eliminate the need for converting the motors as the tape could be driven by a small high-speed motor. The tape would provide a continuous record and would therefore reveal more detail. The pickup coil for the tape could be made of any desired size and could thus serve as a step-up or a step-down transformer.

Another possibility suggested by the use of the tape is that film could be dispensed with if so desired. The motor of the tape-moving mechanis could be turned off or the ignitr output automatically removed fr the magnetizing coil of the tape the surge in the same manner th the film is started in the describe set-up. The tape could then be r at a slow speed through a pick-u coil of a large number of turns a studied at leisure.

WARREN F. GOODELL, JR.
Urbana, Illin

Ground Plane Antennas

IN AN ARTICLE by H. W. Hasenbeck formulas and curves are shown whi are claimed to be values of resis ance and reactance of a vertical a tenna, supported above four quarte wave ground rods. However, it further stated that the data giv by King and Blake[2] were used establishing the curves. The da given by King and Blake apply a symmetrical antenna fed at i center or to a vertical antenn operating against an infinite me sheet. It is the purpose of this di cussion to point out that there is fundamental difference in the a tenna impedance of an anten operating with four ground rods a an antenna operating over a sem infinite sheet. The formula given J. Epstein and the writer[3] was bas upon a consideration of the self-r sistances of the quarter wave a tenna and each of the four grou rods, as well as the mutual resis ances between antenna and grou rods and between ground rods.

Experimental technique is often some little assistance in sheddi light on a controversial point of th

[1] Hasenbeck, H. W., Design Data for Grou Plane Antennas, ELECTRONICS, August 194 p. 98-101.

[2] King, R. and Blake, Jr., F. G., The Se Impedance of a Symmetrical Antenna. *Pr I.R.E.*, 30, 1942, p. 335–349.

[3] Brown, G. H. and Epstein, J., An Ult High Frequency Antenna of Simple Constr tion. *Communications*, July, 1940, p. 5.

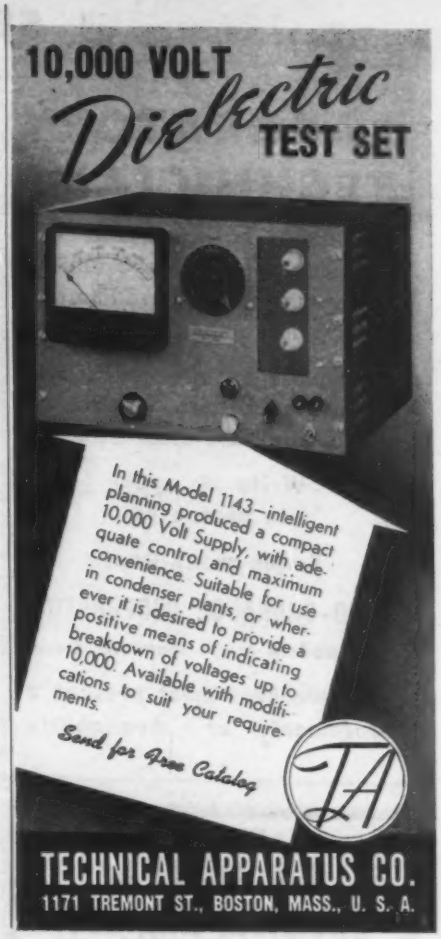
Fig. 1: Arrangement used to measure the resistance and reactance of the RCA MI-7823-A antenna

sort. Accordingly, the arrangement shown in Fig. 1 was used to measure the antenna resistance and reactance by observing the standing wave of voltage on the slotted transmission line feeding the antenna. The operating frequency was 60 mc. The ground rods were made one-quarter wave in length at this frequency, while the antenna length was varied. The antenna diameter was 0.625 inches.

Curve *A*, Fig. 2, shows the antenna resistance measured with this arrangement, while Curve *B* is taken from Hasenbeck's[1] Fig. 4. Curve *C* is the theoretical radiation resistance of a vertical antenna operating over a semi-infinite perfectly-conducting plane, assuming a sine-wave distribution of current along the antenna[4]. The length of the antenna is expressed in degrees, obtained by multiplying the physical antenna length by 360 and dividing by the free-space wavelength, where the antenna length and the wavelength are measured in the same units. One may see from this figure that the antenna operating with four ground rods has an appreciably lower radiation resistance than is generally assumed for the same antenna operating over a semi-infinite conducting plane.

When the antenna was exactly one-quarter wave (90°) in length, the four ground rods were replaced by a metal disc, one wavelength in diameter. The radiation resistance, which

[4] Brown, G. H., Lewis, R. F. and Epstein, J., Ground Systems as a Factor in Antenna Efficiency, *Proc. I.R.E.*, June, 1937, Fig. 2, p. 755.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(Additional Employment ads on pages 340, 341, 347, 282)

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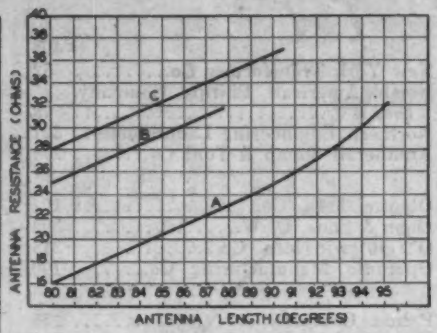

Fig. 2: The measured antenna resistance is shown by Curve *A*, the values given by Hasenbeck are shown by Curve *B*, while Curve C is the theoretical radiation resistance of a vertical antenna operating over a semi-infinite perfectly-conducting plane, assuming a sine-wave distribution of current along the antenna

was 25.0 ohms with the ground rods, now measured 37.0 ohms.

Curve *A*, Fig. 3, shows the measured antenna reactance when the four ground rods were used, while Curve *B* was computed from Hasenbeck's[1] Eq. (8).

For any particular antenna length, the resonant impedance (a pure resistance) that will be presented to the transmission line when the antenna is parallel resonated by the support stub is quickly found from the relation

$$R_p = (R_a^2 + X_a^2)/R_a$$

where R_a is the antenna resistance from Curve *A*, Fig. 2, and X_a is the antenna reactance from Curve *A*, Fig. 3. The resulting curve is shown in Fig. 4. We see that it is practically possible to present a resistance which will match a concentric transmission line of any characteristic impedance above 25.0 ohms. It is theoretically possible to increase the parallel resonant impedance at will by continuing to shorten the antenna, but inspection of Fig. 4 shows that

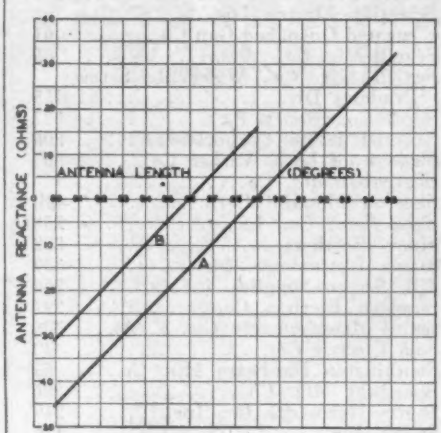

Fig. 3: Curve *A* is the measured antenna reactance, while Curve *B* is computed from Hasenbeck's Eq. (8)

the antenna length becomes extremely critical when resistances in excess of 100 ohms are desired.

The parallel inductance of the support stub which is required to accomplish the parallel resonance may be found from the relation

$$X_s = (R_a^2 + X_a^2)/X_a$$

It may be seen that X_s is inductive when X_a is capacitive, and vice versa. The necessary values of X_s are also given in Fig. 4. In the article by

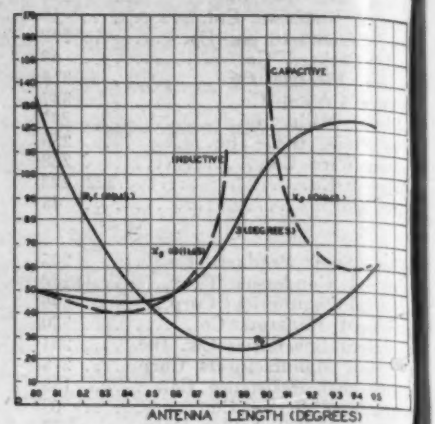

Fig. 4: This figure shows the parallel resonant resistance which may be obtained with the RCA MI-7823-A antenna, as well as the shunt reactance required for resonance and the length of the support section needed to give these reactive values

Hasenbeck, it was assumed that the stub support section had a characteristic impedance of 70 ohms. However, in the RCA MI-7823-A antenna, the stub section had a characteristic impedance of 41 ohms. This was done to lengthen the support section when low frequencies requiring long antenna sections were used, and to make the adjustment of the shorting plug less critical. Then the length, S in degrees, of the shorted section is given by

$$\tan S = X_s/41$$

where X_s is obtained from the above mentioned curve of Fig. 4. The resulting electrical length of the shorted section is shown in Fig. 4. It is interesting to note that the support section is one-quarter wave long when the antenna itself is resonant, shortens up as the antenna is shortened and then increases in length as the antenna reactance reaches high values. In the region of useful operation, where R_p is in the neighborhood of 70 ohms, the length of the shorted section is remarkably uncritical.

GEORGE H. BROWN
RCA Laboratories
Princeton, New Jersey

Power—Giant Arm of Production

Ninety Per Cent of American Industry Is Electrified

ELECTRICITY is the mainspring that turns the wheels of our factories, mills and mines. It is the tireless arm that grinds our grain, weaves our cloth, pumps our water, builds our planes, our guns, our ships, our cars, our trucks and tanks . . .

The mighty Pharaohs had less energy at their disposal in building their pyramids than is generated today by one single power plant. The combined capacity of America's central power systems is without parallel in the history of the world . . . 46 million kilowatts, i.e., 65 million horsepower in steam turbines, hydro turbines and other prime movers. That is more power, day in and day out, than 650 million slaves could produce—for a limited time—minutes in fact.

The capacity of this vast fountain of energy is beyond the grasp of the average man who flips a switch and sets in motion machines that perform the labor of a thousand man-hours in a matter of minutes. Perhaps only the old time farmer, whose traditional source of power is a team of tired horses and a pair of calloused hands, knows how to appreciate this commodity that is so vital an ingredient of everything we consume and use.

Yes, we take electricity for granted. We expect it to appear in unlimited quantities, like water and air, as we need it. Almost as essential as these two elements in times of peace, it becomes a matter of life and death in times of war. Industry would collapse without it and the nation would quickly perish.

With the catastrophe of Pearl Harbor a little over a year ago, came the realization that we had to out-produce our enemies. To out-produce our enemies, who had a seven year head start, meant to turn more wheels than they were turning and to turn them faster than they were turning them.

New plants sprung up overnight. Production increased beyond our wildest dreams. Aircraft and shipbuilding surpassed the most daring forecasts. The machine tool industry's output grew to a volume that bordered on the miraculous. Guns, shells, uniforms, shoes, tanks and a thousand other items were being made in hitherto undreamed of quantities. All of them have one common essential ingredient – power. Industry demanded power – more and more power!

It is no small tribute to the power industry that, while other raw materials developed shortages necessitating strict priorities control, electricity remains unrationed – no priorities, no curtailments, no rate increase. Current industrial consumption is running 16 per cent over 1941 and 50 per cent over 1940. Not spectacular perhaps but when we consider that the nation's 26 million domestic consumers utilize only about 14 per cent of the energy output, we begin to get some idea of industry's power consumption.

Our power companies might have been stunned by the prospect of mounting demands for kilowatts. Instead they set about developing and coordinating a multiplicity of relatively small and seemingly unrelated factors. Individually or even collectively, these have not been of a spectacular nature. Certainly they have not inspired the award of the Army-Navy E although they are an essential ingredient in every Army-Navy E that has been awarded to American industry.

The contribution of the power industry to the winning of the war is not likely to flame forth in newspaper headlines. It takes the more prosaic turn of portraying an industry that is doing wonders quietly, unobtrusively.

At the close of the last war the power at the disposal of the American industrial worker averaged 3⅓ horsepower. At the beginning of this war, twenty years later,

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it had increased to 6½ horsepower. What other nation can even approach that figure? This large provision of power is the achievement of the electric utility industry. For years it had built and applied its equipment to the highest standards of performance and operated its systems to equally high standards of service and dependability. Always recognizing that "public service is a public trust" it had maintained wide margins of security in performance. Today these margins are the source of the power industry's ability to rise to the emergency.

In short, the electric utilities were prepared!

Power men are accustomed to looking ahead, to prepare for growing loads and allow for unforeseen contingencies, for electricity cannot be stored. It is "ordered" by touching a switch. It is delivered and consumed at the same moment.

Months before the actual outbreak of hostilities foresighted power men set to work computing how much life of equipment could be risked in the process of crowding it toward greater output. Generators, boilers, turbines, cables, transformers and even conductors underwent close scrutiny in an effort to increase the load – *safely*. They figured, they experimented, they tried untried measures.

Insulation, for example, is the crux – the least known component of electrical apparatus. When it lets go the service suffers. It is not easy to know how near any bit of crucial insulation is to letting go. It takes courage to work it to a point just short of failure . . . but that is exactly what is being done today.

Technological forcing of equipment, however, is not all of the story. Obsolescent equipment has been rehabilitated; salvage has been intensified; critical metals have been replaced by non-critical materials; water sprays, air-blowers and other cooling methods have been installed to keep over-loaded apparatus from over-heating. Nothing has been overlooked. Ingenuity has contrived the well nigh impossible.

Hand in hand with these measures of expediency have gone measures of intensification. Hydrogen pressure for cooling generators has been stepped up from ounces to pounds taking more heat away from the machines and enabling them to carry greater loads. Capacitors – little more than aluminum foil interleaved with thin paper – have been applied by the carload relieving the systems of that mysterious reactive current which is associated with that equally mysterious power factor. They have performed wonders in avoiding the need for additional generating and transforming equipment. The use of portable sub-stations has averted the otherwise necessary reserve capacity in fixed installations at many points.

When coal was placed on the urgent list last spring the electric utilities outstripped all other industries in providing storage for the winter. Stocks on hand the first of October were sufficient for 105 days, or more than twice what would be considered adequate in times of peace.

When staff losses to the armed forces became serious power companies contrived measures that enable them to get along without aggravating the national manpower situation by hiring others to replace them. Today meters are being read every two or three months instead of monthly; women are being trained to do drafting, keep the logs in power plants and sub-stations and to test meters in shops and laboratories.

On the summit of "Grandpa's Knob", a mountain overlooking Rutland, Vermont, stands a giant windmill that would have been the delight of Don Quixote. Towering 200 feet above the tree tops its mighty 175 foot propeller turns with the wind and drives a 1,000 kilowatt generator which feeds its output into the Central Vermont Public Service Corporation's power system. The most ambitious wind-turbine generator in the world, and a daring experiment of forward-looking men.

Today everything electrical is being tried; is being worked harder than it has ever been worked before.

Great credit is due the men behind the electric power industry. These men have recognized the responsibility of their jobs – it is a part of their very being. Theirs is the kind of service that must be maintained. No soldier is truer to his trust than is the employee of this great industry.

The service must go on! No matter what happens – acts of God or deeds of men – the service must go on! Labor disturbances may disrupt other industries but there have been no shutdowns due to labor trouble in electric power plants since Pearl Harbor.

And this winter when blizzards pile up drifts and sleet makes pavements slippery there may be absenteeism from other plants but the utility employees will be on the job ready to climb the ice-covered poles and repair the ice-laden lines whenever the call comes.

In this war the least costly yet the most precious element of production – electricity – will be ever ready to "man" the machines that will produce the weapons that will give victory to the forces of freedom.

President, McGraw-Hill Publishing Company, Inc.

Mining—Number One War Industry

The mineral products of the earth are the prime necessities of war... and peace

THE SURFACE of the earth provided primitive man with the things he needed for his meager existence but civilization really began when he became curious about its interior. This curiosity has brought us a long way. For the earth has yielded — out of its deep recesses — all the raw materials of modern industry. And today, in the grueling race of production, our mining industry is providing the raw materials upon which depends our survival. Our mines and quarries must supply a long list of materials without which a successful war cannot be fought.

Take steel, for example. War without steel is inconceivable. Steel starts with iron ore, limestone and coke. These are products of mines and quarries. It takes power and heat to get these materials out of the ground, to refine them and to transport them to the point where processing begins. All the subsequent operations culminating in the steel ingot, shape or plate, and in moving the final product to the point of use require power and heat.

The major source of this power and heat is coal.

Production of a ton of steel, it has been stated, requires two tons of coal. Smelting of the pig iron alone, 60,000,000 tons in 1942, required the coking of some 75,000,000 tons of coal. Pig output is expected to rise to 68,000,000-70,000,000 tons in 1943, carrying coal consumption up to 85,000,000 tons. At the same time, output of steel ingots is expected to rise from 87,000,000 to 97,000,000 tons. Think what this means in terms of power and heat.

Another vital metal is copper. Modern armies need copper. This point is dramatically illustrated in a recent memorandum by Robert P. Patterson, Under Secretary of War, in announcing the release of 4,000 men from military service to return to the mines and increase copper production. "In a single minute of combat", Mr. Patterson declared, "a flight of 50 fighter planes shoots away 7 tons of copper. A 37-mm. anti-aircraft gun uses up a ton of copper every twenty minutes it is in operation. Six hundred pounds of copper go into every medium tank, and a ton into the engines and airframe of a Flying Fortress. The Signal Corps alone needs 5,000 tons of copper every month for radio and telegraphic and telephonic equipment. An army without copper would be an army without speed, maneuverability or firepower. It would not last a day in battle".

Seven tons of copper for one minute of combat by 50 fighter planes means from 200 to 700 tons of ore, depending upon its grade. Small wonder that the War Department was willing to release drafted miners from military duties to produce more copper.

But other metals are equally important in war: tungsten, nickel, manganese, chromium, vanadium and molybdenum for alloy steels; zinc for brass and die castings; tin for bronze and bearings; aluminum and magnesium for aircraft; lead and mercury for ammunition; silver for electrical equipment, bearings and solder, and so on. Even relatively insignificant non-metallics, like mica and diamonds, suddenly assume critical importance.

And let us not lose sight of the fact that without adequate energy, i.e., heat and power, production, processing, transportation and the relative comforts to which we have become accustomed would be impossible under war conditions. Coal is the major source of energy in the United States. It supplies more than half the total in normal years.

The railroads of the country alone used 110,000,000 tons in 1942 to move freight and passengers and service their facilities. Utilities consumed over 68,000,000 tons in the production of electric power. Over 135,000,000 tons of coal were consumed last year in maintaining the level of heating comfort necessary for the maintenance of efficiency and morale. The consumption, this year, will be even greater.

In short, the mineral products of the earth are the prime necessities of war.

The nations that control the world's mineral resources and make the most efficient use of them will win the victory.

Before the war, the British Empire and the United States together controlled probably 75 per cent of the world's mineral production. This would have been a most potent weapon in the United Nations' arsenal if the whole strategy of Axis expansion had not been influenced by mineral objectives. Addressing the American Zinc Institute on the subject last April, E. W. Pehrson, of the U. S. Bureau of Mines, estimated that the Axis had improved its position in world mineral resources in the following percentages: iron ore, from 6 to 46; steel production capacity, 20 to 34; petroleum, 1 to 7; coal, 27 to 53; copper, 5 to 10; lead, 7 to 22; zinc, 16 to 27; tin, 1 to 72; manganese, 2 to 30; chrome, 3 to 30; tungsten, 6 to 60. In the light metals, areas now Axis-controlled produced in 1940 54 per cent of the world's aluminum, 49 per cent of the bauxite (the principal source of aluminum) and two-thirds of the magnesium.

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Despite these gains, the industrial war power of the United Nations still can outweigh that of the Axis by a considerable margin. It already has begun to surpass it. The problem is to convert quickly our potential mineral resources into implements of war. In this conversion, a heavy burden of responsibility has been placed on the mining industry of the United States as the largest producer of many metals, minerals and fuels. In fact, the United States mining industry began to go on a war basis a year before Pearl Harbor. The curves of demand for domestic copper, lead, zinc and other metals began to rise sharply in 1940, and were paralleled by a rising coal production.

How well the job has been done cannot be revealed in accurate figures in many cases because of censorship. In metals, however, some idea of production gains can be indicated in comparative terms. United States copper production, for example, is breaking all previous records. Aluminum capacity will be more than seven times its annual peace-time average. Magnesium plants now building will have a capacity 100 times the largest yearly before-the-war figure. Molybdenum, of which the United States has the largest single mine in the world, is being made available in record quantity. Zinc, lead and mercury are surpassing expectations in meeting wartime demands, and tungsten, chromium, manganese, antimony and iron and steel are being turned out in record-breaking quantities.

Bituminous coal production in 1942 was 580,000,000 tons, the greatest in history, valued at more than $1,300,000,000 at the mine. Some 430,000 or more men were employed in 1942 and received at least $750,000,000 in wages. Bituminous production in 1939 was 394,855,000 tons, while the output for 1943 is forecast at approximately 600,000,000 tons – another new United States record. The 1942 anthracite output was 59,961,000 tons, valued at over $270,000,000 at the mine. The industry employed some 85,000 men and paid out at least $180,000,000 in wages. The 1939 production of anthracite was 51,487,000 tons, and the forecast for 1943 is 65,000,000 tons or more.

Marshalling the Western Hemisphere's mineral resources, the United Nations have been the beneficiaries of the diversified resources of two continents – in particular of Canada's nickel and coal, Mexico's lead and antimony, Chile's copper, Bolivia's tin, Peru's vanadium, Brazil's iron, and Venezuela's petroleum. With other United Nations contributing their share of metals and fuel, the grand total is an impressive array of potential munitions and matériel to lend assurance of certain victory over the Axis. Sheer weight of metal, properly used, will win the war, and our mineral industry will have played an indispensable and essential part in the inevitable outcome.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.

Food—The Deciding Issue

Our food problem remains to be solved

THE first thing the Germans did when they occupied Czecho-Slovakia, Poland, Belgium, France – was to empty all warehouses. Everything went into trucks headed for Germany.

The Nazis knew that this war would be won by the army that had the most supplies and the best supply system.

The Nazis knew that supplies are as essential as guns. They knew that the most essential of all supplies is . . . food.

Being the only people on earth who can watch women and children starve, the Nazis seized upon food as their most powerful instrument for disciplining the masses. They added famine to their arsenal of conquest.

The flocks and herds of Europe are being consumed with alarming rapidity. The desperate shortage of meats and fats is growing steadily worse. Our Allies are short of certain foods that we must supply if we expect them to carry on.

And as we supply them, as our imports are curtailed, as our fighting men consume more than they do in civil life, and as we fail to increase our production rapidly enough . . . we, too, become short of certain foods.

Former President Herbert Hoover, speaking before a conference of the Governors and Representatives of twelve Mid-Western farming states in Des Moines on March 15th, sounded the warning that American agriculture, beset by Washington bungling on manpower, farm machinery and price systems, strangling production and distribution, is facing a deterioration which may bring on a national food shortage such as led to the collapse of Russia, the defeat of Germany in the first World War and the fall of France in the present war. Unless this deterioration is stopped, warns Mr. Hoover, we cannot hope to win the present conflict.

Complications of similar magnitude face the food processor and the distributor.

Never in the history of the world has man's dependence on food been so crucial. Yet it is not easy for us to grasp the full significance of the crisis. We are so accustomed to finding milk, eggs and butter on our doorsteps every morning, we are so used to filling our pantries from the shelves of our grocers and markets that we accept food as something that is due us on demand. We do not stop to think that we never are more than a few meals ahead of famine.

But this picture has changed. Now we are faced with food rationing, and every day the shelves of our food markets become more bare.

* * *

Let it be noted that the appointment of two Food Administrators has not solved the food problem. It is still with us; daily it becomes more critical. Unless it is solved, and solved quickly, the very food that ex-Food Administrator Wickard said would "win the war and write the peace" may lose the war and lose the peace.

Put very simply and clearly, the food problem amounts to this: we are trying to feed upward of 200 million people. We are trying to do it with the farms and other facilities that heretofore have been capable of feeding about 145 million people (our present population plus a 5% surplus).

Had the Government foreseen the need and planned ahead, we could have begun by 1941 the enlargement of our farm production and food processing capacity. Two irreplaceable years have been lost!

The gravity of the situation becomes apparent when we consider that 50,000 factories are required to process our foods. Food processing not only is America's biggest industry – it is one of America's most important for, without processing, most foods would perish before they could reach the consumer. The term "processing" covers the salting, drying, smoking, pickling, chilling, canning, packing and other methods of preservation that make it possible for us to eat in 1943 food that was produced in 1942. Few realize that most of the food we shall eat in 1943 was produced and processed last year, that most of the seed we plant this spring will grow food for 1944 or perhaps later.

In one important process of preservation, tin and rubber are vital materials. When the Japs captured Malaya and the Netherlands East Indies more than half of the world's tin and nearly all of its rubber fell into their hands. This forced drastic changes upon our entire food economy. The importance of tinplated steel containers, tops for glass jars and rubber gaskets is fairly obvious . . . metal food containers alone consume, every year, more than 2,700,000 tons of steel.

The aggression of Japan has snared our whole food industry in a maze of intricate packing problems. It has enforced recognition of a new principle of food technology, i.e., that the *method* of food preservation is determined by the *type* of container available. The tin, steel and rubber stringency compels many food processors to adopt

unfamiliar methods – methods that call for a great deal of new equipment. This, in turn, involves the use of critical materials that are so urgently needed for other war purposes.

This conversion of the food processing industry to meet these exacting restrictions has been greatly complicated by two factors that have increased its wartime burden. Indeed, it is these that provide the principal reason for civilian food rationing.

The first of these is the task of feeding our armed forces overseas. Allied ships are being sunk at an alarming rate and the loss of cargo is considerable.

The second factor gravely augments the first. Under Lend-Lease our country is undertaking to feed our Allies to the extent of approximately 60 million people.

Types of food required for Lend-Lease and the armed forces are the finest we can produce. They are the high protein foods, especially meats, cheese and milk; and the protective foods which rate high in vitamin content. Peculiarly enough, the more valuable a food is from a nutritive angle, the more specialized is the processing required to preserve it.

The food processing industry, handicapped as it is, is meeting today's challenge with resourcefulness and enthusiasm . . . despite container complications and shipping shortages.

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It is accomplishing its Herculean task by resurrecting and modernizing a method of food preservation that is as old as mankind. Probably you have read a great deal about dehydration. You actually may have eaten dehydrated food, but right now nearly every bit of dehydrated food is earmarked for the armed forces or for Lend-Lease.

Food processing never will be as spectacular as the production of bombers or tanks. But under today's conditions, the performance of the food processor is no less important . . . no less inspiring. When we consider that dehydrated food is compressed into solid blocks with a density nearly equal to that of coal, so that almost a whole meal can be carried in a vest pocket, and that half of the shipping space is thereby saved in transportation, we begin to appreciate what the processors have contributed to meet the food problem imposed by the war.

But they have not only contributed new methods, they are achieving new highs in production. And now they are asked to do what borders on the impossible. Consider dehydrated egg powder. Normal production in pre-war years was about 3,000,000 lbs. In 1940 this was increased two and one-half times, in 1942 it was stepped up again this time forty-fold. And in 1943 the call is for another 60 per cent boost, to make a total of 480,000,000 lbs. Dried milk powder production of 350,000,000 lbs. in 1940 must be increased to 685,000,000 lbs. in 1943.

Vegetables, which were a small item to the processor before the war, now are dehydrated in enormous quantities. The vegetable dehydration industry has had to grow by leaps and bounds without benefit of the high priorities accorded to arms, ship and aircraft building. Production of dehydrated vegetables in 1942 was four times that of 1941, and 1943 calls for a sixteen-fold increase over 1942.

Total dehydrated food production in 1943 is scheduled at 1,750,000,000 lbs., dry basis . . . *all for export.* Multiply that by 10 and you have a rough approximation of the astronomical amount of raw materials that will have to be produced.

Many problems remain to be solved in the troublesome days that lie ahead. But with all his resourcefulness, man has little control over the weather. A severe drought could wipe out all of man's carefully laid plans. If we are tempted to reassure ourselves with the thought that the food situation probably is not so serious as it is painted, it will be well to remember that last year's crop increase over 1941 was due to better than average growing weather.

The war-bred food crisis that now confronts us will be met only by immediate measures to insure a food production ample to allow for adverse weather conditions. The food processing industry is capable, but has not been granted the needed help, in coping with its tasks. The food problem as a whole involves all three functions of production, processing and distribution. And if we are to master the problems that now beset us, all three of them must be coordinated under a single administrative control. "Food will win the war and write the peace". But if American food is to do that double job, we must develop a capacity for food administration comparable with the genius of our food industries.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.

TRANSPORTATION—a vital war factor

The effectiveness of our armed forces and civilians alike depends on the efficiency of our transportation

As the battle of Tunisia entered its final phases, with the British and American forces joining hands to crowd Rommel into his last fox hole, Hitler and Mussolini held their twelfth war-time meeting.

One important purpose of this meeting, according to the Berlin radio, was the study of a specially prepared "Survey of Continental Reserves". Topping this list of resources is the item of transportation.

Hitler has a great many headaches these days but, according to no less an authority than the Reich Ministry of Economics, "the central problem of the whole German war effort is transportation". It is, in fact, the Achilles' heel of Germany's War Machine.

The Nazis have become soberly conscious of its crucial importance and Mr. Hitler must wince when he recalls the gigantic miscalculations which led him to neglect his railways.

He counted on a short war, not a long wear-and-tear war and Germany's transportation crisis is getting more critical by the hour. It will play a vital part in its defeat.

This is a war of movement—on land, on sea and in the air. Russia's 2,000 mile battleline, R.A.F.'s 700 mile bombing raids, General Montgomery's 1,500 mile advance last November and the vast area that constitutes the theatre of war in the Pacific make this fairly obvious.

Peace will come when one side gets control over the world's supply of fuel, oil and rubber, for on these three critical materials depend all the vehicles of war—as well as of peace.

An army used to travel on its stomach. Today it travels on its fuel tank.

On the home front, transportation is no less vital. Here it is essential in getting the war workers, their raw materials and their products, to and from the mines, mills and factories that supply our armed forces and those of our Allies. Transportation is a major factor in the nation's ability to out-produce its enemies. Every known method, every type of vehicle becomes essential, for no single group of carriers, freight or passenger, can meet all our needs.

The railroads opened the vast resources of our nation and continue to be the backbone of our transportation system. Today they are doing the greatest job in their history. They are hauling more tons of freight more miles than ever before—33% more than in 1941 and 55% more than in 1918, peak year of the first World War. They are carrying more passengers more miles than ever before—80% more than in 1941 and 24% more than in 1918. They are getting more work out of each car, each engine, and each mile of track than ever before. Private operation of railroads is proving far more effective and efficient in this war than did government operation in the last war.

In contrast to Hitler's Germany, the managers of the American railroads have not neglected their plant except where government priorities forced them to do so. They are turning in an unprecedented performance despite the long starvation period to which they were subjected. During the first World War the total investment in the American railroad plant was about $18,600,000,000. Since then $12,000,000,000 have been spent on improvements and after deductions for scrapped facilities the net increase has been $8,000,000,000. Since the present war in Europe began the railroads have invested about $1,650,000,000 in further improvements, many of them to meet special war needs.

Convincing evidence of the railroads' flexibility in meeting the special needs of all-out war is their performance in coping with the movement of oil to the East Coast. In January 1942, one month following Pearl Harbor, the railroads delivered to the East Coast by tank car less than 100,000 barrels daily. By December they had stepped this up to more than 740,000 barrels and during the week ended April 3, 1943 they

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Electrical Equipment—Weapons and Tools

From miniature motors to mammoth generators, from tiny detector tubes to great broadcasting stations—everything electrical is essential to our war effort

AS this editorial goes to press, newspapers and radio news commentators are telling the dramatic story of the blasting of two mighty Nazi power dams. Floods are sweeping down the Ruhr Valley, Germany's most vital munition production center. Two vast networks of industrial activity lie inert, for the great generators that had fed power to hundreds of plants producing war goods for Hitler, today stand idle. This daring raid will go down in history as one of the most, if not *the* most devastating of the entire war. It has destroyed two great sources of power, stopping the wheels in hundreds of plants and throwing into darkness thousands of factories and homes.

This epoch-making raid by the R.A.F. brings home to us the vital importance of our own power resources, those colossal generators from which flows the current that turns the wheels of our great industries, illuminates our factories and homes and runs our electric railways and subways. It makes us realize how dependent we are on electricity and how important is the part of those manufacturers who produce the electrical equipment that makes possible its generation and use.

Beginning with Thomas A. Edison, the inventive genius of electrical manufacturing men has devised more and more efficient ways of generating the current, better and better means of transmitting it and of applying it to do thousands of jobs quicker and better.

The products of electrical manufacturers have become so completely an essential component part of every industrial, business and domestic activity that our economy and our war effort could not go on without it.

In days of peace the laboratories of our electrical industry gave us radio, fluorescent lighting, infra-red drying, precision process-control, telemetering, split-second circuit breakers and many other things that border on the miraculous.

Today their facilities and their genius are devoted to an all-out war of wits with Axis scientists and production men.

Electricity plays a significant part in this war . . . from the "walkie-talkie" that brings support to hard-pressed outposts, to the mammoth motors on the battleships. While many electrical developments today are cloaked in secrecy, the nation will enthusiastically applaud these electrical manufacturers when the curtain is lifted.

The far-reaching importance of electrical instruments, apparatus and machines becomes evident when we consider that over 350 different electrical items go into combat vessels and that more than 170 go into a fighter plane. Most of these products are distinctly special in nature and are far removed from their civilian counterparts if, indeed, they have such counterparts.

To the civilian, a light bulb is something so standardized that every need can be filled by any nearby dealer. Our armed forces, by contrast, must have at their disposal more than 400 distinct types of lamps. Some no larger than the head of a match, are so brilliant that they flash signals under a tropical noon sky. Others are built to withstand extremely low temperatures, vibration, shock and many other abuses to which they are subjected.

On planes, for example, numerous fractional-horsepower motors are used but the standard industrial motor is not suitable for this service. New records in low weight-per-horsepower had to be achieved involving extensive changes in design and production.

To prevent the light from instrument panels from impairing the vision of night fighters, ultra-violet radiation which activates fluorescent instrument dials was developed. As a result, the pilot may look out into the darkness after reading his instruments without the least effect on his eyes. How many precious air victories can be credited to this one development alone?

But, in general, the story of this industry's war work is much too blurred by military censorship to afford an adequate picture of its contributions. The factories and shipyards that are turning out war matériel tell a more complete story. Many of these have been built during the past two years. Others have gone through a complete conversion process. In every case, large quantities of electrical materials were involved.

In the broadest sense, there are three major jobs which this industry has had to do, in addition to equipping our modern war machine. It has had to supply materials for the vast expansion of our industrial system, keep every plant fully maintained, and provide the necessary equipment for the vital power and communication fields.

More than $1,900,000,000 was spent for new industrial construction in 1942, and of this about 7% or $140,000,000 was for electrical materials. New machine tools and other production equipment required an additional $350,000,000 worth of electrical products. The conversion program called for another $145,000,000 of electrical apparatus and supplies.

This total of over $600,000,000 in itself would have staggered the electrical industry in a peace-time year. Yet, this record-breaking production was essential and had to be superimposed upon the direct requirements of the Army and Navy.

Industry depends upon electricity. Consider for a moment the effect of modern lighting upon war production. Industry enjoys levels of illumination and color quality that were undreamed of ten years ago. As a result, midnight shifts operate at daytime efficiency. As a matter of fact, many of the more modern plants have no windows at all.

Then there is maintenance. The failure of one single motor or feeder will stop a production line. Electrical manufacturers have had to stand at all times ready to

averaged more than 900,000 barrels per day. By the end of this year they are shooting for the goal of one million barrels a day.

Unlike Germany we have not attempted to control the development and growth of motor transportation according to the "intuitions" of one man but have wisely left it in the hands of experienced competition. That is how our highway transportation system came into being. Growing public acceptance has made it an essential part of our national economy.

The motor vehicle, its limitations set only by the improved highway and the supply of fuel and rubber, has developed to undreamed of proportions. Up to a year ago private automobiles consistently moved more people more miles than *all public carriers combined*. Buses have become an accepted means of mass transportation. Local electric and interurban railways in many cases were converted to bus lines and trucks took over the local freight services. Under these improved operating conditions traffic volume increased. When the war in the Pacific made it necessary for us to conserve our supply of rubber and the U-boat depredations in the Atlantic throttled the flow of gasoline to the eastern seaboard, our motor transport was forced to grapple with the toughest problem that ever had confronted it since it became so vital a factor in the every day transportation.

The "share-the-ride" idea recognizes the need of conserving gas, oil and rubber. This particularly applies to buses, for wherever groups can be assembled for a common destination, buses can be used most effectively. The intercity bus performs for the rural areas the same service that the local bus renders for the residential areas of our cities.

Reorganization of railroad schedules, adaptation of motor transport, rearrangement of working hours, all have contributed to provide a flexible transportation service for men and materials to meet the critical needs of the war effort. Twenty thousand intercity buses are handling 635 million passengers a year which is 69 per cent more than in 1941. The fact that these buses carry a relatively larger percentage of the total coach passenger business than their seating capacity would indicate suggests that here, too, we are getting a more efficient use of these vehicles in terms of passenger loads carried. It is fortunate to note that the geographic location of most intercity bus lines does not coincide with that of the railroads but rather supplements it.

The contribution which the urban transport industry is making to the war effort becomes apparent when we consider that buses, trolley buses and street cars today carry passengers at a rate which promises to exceed the impressive total of 21 billions, as compared with 18 billions in 1942 and an average of 13½ billions for the period 1936 to 1941. And this the industry is accomplishing with a minimum of added equipment and despite a serious drain on its manpower.

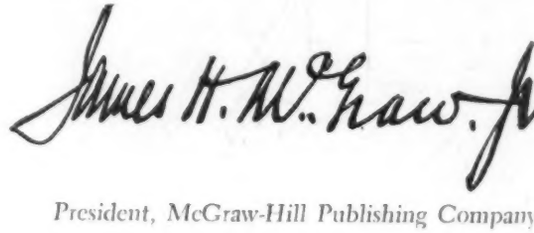
The truck lines, too, are setting all-time records. They have rearranged their schedules, eliminated circuitous routes and coordinated their services with those of other carriers. As this is written, contract truckers with the cooperation of the Office of Defense Transportation are trying to eliminate the empty return trip.

The transportation industry as a whole is face to face with the biggest job in its history. Increasing traffic loads, with little if any new equipment, difficulty in obtaining essential maintenance materials and a growing shortage of manpower, combine to make it that. While federal authorities, acting through the Office of Defense Transportation, took prompt cognizance of this condition, froze equipment and otherwise acted to conserve the vehicles then in service, it was not possible to add sufficient vehicles to keep pace with the increased traffic demand. However, the O.D.T. did lend impetus to the movement for staggering hours of work thereby spreading the peak loads and thus increasing the carrying power of existing fleets of vehicles in city service.

As we review the problems involved in meeting our transportation needs it is evident that we cannot depend upon new equipment alone for their solution. Lend-Lease is taking a considerable share of our much needed output of transportation equipment. The immediate job is up to the rank and file of the transportation industries. It is up to their resourcefulness and devotion to their job. The operating men out on the road, the men in the shops who keep the equipment going, who make the most of the metals and other materials they can have, who salvage, conserve and economize . . . these are the men who must bear the burden of our war load.

Theirs is a dramatic story, a story of cooperation and coordination . . . of ever increasing capacity on a shoestring allowance of new equipment.

For this is a war of movement. According to Joseph B. Eastman, Director of Defense Transportation, both the passenger and the freight traffic on the railroads is to a large extent war traffic – the transportation of troops and civilians on war business, the movement of food, raw materials and finished products required for the prosecution of the war. As Mr. Eastman put it, delayed arrival of troops at embarkation ports, delayed delivery of vital war materials could even conceivably mean the loss of men at the fighting front. And what Director Eastman says of the railroads applies to all forms of transportation. Transportation by bus, by street car, by truck, by train, by ship and by plane . . . all play a vital part in the achievement of victory . . . on the home front and on the fighting front which relies upon it.



President, McGraw-Hill Publishing Company, Inc.

Engineering Design
—Creator of America's Mechanized Might

In war, as well as in peace, the design engineer is the vital link between the inventive mind and the mass-production reality

IT IS gratifying and interesting to note that reports of new "secret weapons" not only have reversed their course during the past few months . . . they also have increased in frequency. Once they filled us with dread and misgiving. Today the enemy does the worrying.

Word about the latest new Army weapon reached us as this was being written . . . a 2½ ton truck that performs on water as well as on land with equal efficiency. "The Duck", resembling an overgrown amphibious jeep, is particularly suited to landing operations where docks are lacking. Loaded with 20 fully equipped soldiers or their equivalent in supplies, its propeller runs it ashore. It climbs the beach on its six-wheel drive and continues the trip on land.

This important addition to our "second-front" fighting equipment, coming so closely on the heels of the now famous tank-killing "Bazooka", is one of many history making contributions of American design engineers — the men who transform nebulous ideas into practical realities — the men who make our war machines superior to those of our enemies.

Invasion and eventual victory became a certainty as soon as America's design engineers threw their full effort into the war against aggression. Adapting intricate ordnance designs to mass production, these men developed weapons such as the M-10 destroyer of Rommel's tanks and brought out the new fighting planes and bombers that have won the air superiority that has turned the tide against the Axis. Taking ideas and giving them form, selecting the materials of construction, deciding upon the method of fabrication, adapting the electrical and mechanical parts that power the product, specifying the finish that protects and beautifies it . . . these men are the focal point of American production. Their ingenuity has no parallel. Once they put automobiles on a mass production basis and within the reach of all. Today, after less than three years and with little previous experience in armament design, they have brought America's war weapons to the highest efficiency . . . surpassing Hitler's weapons despite all the vaunted scientific wizardry of the Germans and their ten year start.

At this point it is well to remember that while Germany's military might is traceable to its superiority in armament, many of the basic technological discoveries (including the airplane and the submarine) are the products of American genius. The Germans always have been aware of the military advantages of technological superiority and have forced its expansion with all their might. They knew that mobility and surprise play a decisive role in modern warfare and their design engineers were kept busy, with unique intensity, to achieve unprecedented results in fast-moving, hard-hitting fighting equipment. Our own military and industrial engineers did not go into action until it became certain that we would be involved in the conflict. But even before our country actually embarked on its Preparedness Program they were busily engaged in developing the designs of our war equipment. Tanks, planes, guns, ships and hundreds of other apparatus and machines of war were studied. Carefully selected committees of our national engineering societies were organized under the leadership of the Army Ordnance Department to serve as advisors and consultants in the development of advanced designs of tanks and other motorized equipment of war. The above mentioned "Duck" and the now famous Sherman tank are just two of the many results of these efforts.

After the Preparedness Program had officially been launched and Congress had made its initial appropriation, it was necessary to create the manufacturing blueprints from which the engines of war could be built. Because the designs of the machines of production, as well as the designs of the products themselves, determine the speed and economy with which anything can be manufactured,

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supply the heavy demand for the maintenance and repair parts that keep our industrial machine operating at top speed. Excess loads, 24-hour schedules and inexperienced production hands combine to shorten the lives of electrical equipment.

Electrical manufacturers have had to supply the greatly expanded needs of our power and communication systems.

New construction of all sorts — war plants, cantonments, war housing — has created a formidable need for additional capacity. Every element in our domestic economy has called for increased communication and power services. All this had to be superimposed upon the vast demands of our armed forces. The magnitude of this task is obvious but it is being successfully accomplished. Every old installation is functioning smoothly and every new one has been ready to function on exact schedule. There has been no failure either in our power or in our communication. Part of the credit for this performance belongs to the hundreds of manufacturers who delivered their products when and where they were needed.

This was not merely a problem of increasing production. These manufacturers had been depending on rubber, copper, aluminum and steel — all highly critical materials. For much of their non-military production they suddenly had either to find substitutes or practice the utmost economy and ingenuity.

This is the twelfth of a series of editorials appearing monthly in all McGraw-Hill publications, reaching more than one and one-half million readers, and in daily newspapers in New York, Chicago and Washington, D. C. They are dedicated to the purpose of telling the part that each industry is playing in the war effort and of informing the public on the magnificent war-production accomplishments of America's industries.

Solutions to many problems were quickly found. Lighting manufacturers greatly reduced their use of steel by designing efficient, non-metallic reflectors. Wire and cable manufacturers expanded their use of synthetic insulation in place of rubber and they promoted the use of higher distribution voltages so that every ounce of copper would work more efficiently.

Steel is essential in apparatus that operates magnetically. There is no known substitute. But marked economies in its use have been achieved through the development of new alloys that are of increased magnetic efficiency. As a result, motors and transformers now consume substantially less steel than did units of equal capacity a year or two ago.

Electrical manufacturers have given our industries numerous new production tools. Infra-red heating tunnels, for example, have drastically reduced the time involved in production drying . . . in some cases from hours to minutes. High-frequency induction-heating has been spectacularly successful in the forging, brazing, hardening and casting of ordnance. Modern welding equipment makes possible speedy production with inexperienced labor.

America's production lines are being patrolled by electrical devices which eliminate human error. One million volt X-ray equipment looks through castings and points an unfailing finger at defects. An electronic flaw detector tests nonferrous drawn-metal tubing for imperfections. Other electronic devices are counting and sorting the products of thousands of war plants. Precision controls regulate all sorts of processes, from aluminum production to armor plate annealing.

These are but a few of many examples of the way in which the magic power of electricity has been harnessed to the war effort. Back of every development there is at least one electrical manufacturer — more often many — who have pooled ideas and methods with no thought of royalties or dispute over cost allocation.

No story of the electrical industry would be complete that did not pay tribute to those manufacturers who have dropped their normal lines in order to produce special war products. Many appliance manufacturers fall in this group. When war came, they did not stop to argue that civilian morale and big pay checks would demand a continued supply of their products, instead they quickly shifted to the production of war matériel and today they are deep in the manufacture of machine gun parts, aircraft sub-assemblies, and even gas-mask fabric. They have had to abandon their hard-won markets for the duration; but they are contributing mightily to permanent peace and a more prosperous world to which they will return when the guns are silenced.

This great industry has increased its production threefold in two years — $2,500,000,000 in 1940 to $7,500,000,000 in 1942. It has done this with all the zest of youth, for this is a young and a pioneering industry. Few companies in this industry are fifty years old; the majority are much younger. Top management in general is young, too, and many outstanding technical developments have come from the brains of men just a few years out of college.

The results of all its intensive intelligent work can be found in every factory, on every battlefield and ocean, and even in the flak-spotted air over Berlin. In a sense, the electrical manufacturing industry stands beside every soldier and every sailor as he goes into action. It has a place of honor it richly deserves.

And when this war passes into history, as it surely will, our soldiers and sailors returning to peace-time jobs, will find a life greatly enriched by electrical developments that were undreamed of yesterday.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.

Management
—Heart of America's Industrial Progress

In Peace and War, Management Men and Methods Steer Production on a Steady Upward Course

WHEN the Allied armada of 2,000 ships, protected by a vast umbrella of planes, struck the coast of Sicily, Axis leaders once more had reason to wonder how "that decadent, pleasure-loving America" had swung from the manufacture of automobiles, refrigerators and costume jewelry to equipments of war, and had out-produced such mighty plants as the Krupp, the Fiat and the Skoda works — and had done it so quickly.

America at war is in the lead just as it has led a world at peace. Super-performing planes are taking to the air at the present rate of nearly 100,000 per year. Ships, to carry the war to our enemies, slide down the ways at the rate of two a day. Tanks, trucks, guns, ammunition are pouring out of our "peace" plants in far greater volume than the entire Axis effort can possibly equal. War expenditures in 1943 alone will reach the staggering figure of approximately $83,000,000,000 — an amount equal to our entire national income for 1929. Added to this is the rock-bottom output of essential civilian goods — a very considerable item.

This unprecedented production is taking place while some 9,000,000 men and women, those physically best equipped, have been called to the armed forces. Many of them were taken from industry, and their loss could be repaired only by more efficient equipment and more effective methods.

Rigorous training programs had to be superimposed upon many other abnormal problems facing industry in its high-speed conversion from stoves to boats; from printing machines to guns; from automobiles to airplane engines; from fishing tackle to bomb sights.

This phenomenal task was further complicated by the need for rapid expansion. A modest machine tool industry had to be expanded to handle a volume many times its normal capacity. Steel production had to be increased by 20%, and that of aluminum and magnesium multiplied over and over. From almost nil, the demand for high octane gasoline soared to unbelievable quantities. The creation of synthetic rubber and electronic industries was necessary almost overnight.

Who deserves credit for these accomplishments? All industry! The engineers, chemists, designers, skilled workers, common laborers. But over and above all it belongs to *management*.

In industry it is mandatory to have a directive force to co-ordinate the efforts of men in the use of materials and the application of power toward the production of goods and services. The application of this directive force is the function of management, and only because we had today's kind of management were we able to transform ourselves, almost overnight, from a peace-loving nation to the world's greatest producer of implements of war. As a nation, we had been preparing for a long time to play our part in world affairs. This preparation, certainly not planned for today's objectives but none the less effective, began some four decades ago.

With the advent of the twentieth century, the character of industry in the United States, and, therefore, the character of American living, began to change. Scientific management was born. Frederick W. Taylor brought into focus and showed how to use effectively those processes and procedures upon which our present-day mass production is based. He was followed by Harrington Emerson, who made the industrial world acquainted with efficiency in manufacture and the remarkable progress to be gained therefrom in the field of production, with its consequent price reductions and wider distribution of industry's products. There followed, in industry, an alert management, a capable management, a management with vision. Without it, the work of Taylor and Emerson would have gone for naught.

It is because of this early work of management — and the extraordinary developments it produced — that the country as a whole, and particularly those employed in industry, were not over-awed by the seemingly impossible job of quick conversion to all-out war production. But let us look back four decades and examine some of those preparatory accomplishments which have proven so vital to the progress and welfare of the nation.

From 1900 to 1939 (the last pre-war year), total employment of all kinds increased 52 per cent; in the manufacturing industries alone the increase was 84 per cent. *The nation became definitely industrial.*

In 1900 the average wage earner was able to spend only 20.2 per cent of his income for things other than necessities; in 1930 his buying power for non-essentials had increased to 34.8 per cent. *The average man acquired confidence in what industry could do.*

In 1900 the average work week was 56 hours; in 1930 it was 48 hours. *The burden of production was being transferred from man to machine.*

In 1939 the United States possessed 30 per cent of the world's railroads, 72 per cent of its automobiles, 49 per cent of its telephones. *The nation's production equipment had grown to formidable proportions.*

In 1939 nearly half of the families in the United States owned their own homes, 64 million individuals carried life insurance policies and 45 million had savings accounts. National income had increased 300 per cent from 1900 and during the same period the proportion of national income paid out in salaries and wages increased from 58 to 70 per cent. And in less than this period (1914–1939) the purchasing power of the wage rate increased by 60 per cent. *There had been evolved the kind of living for which men will work — and fight.*

Since 1900, factories increased their output of goods from $11,000,000,000 to $60,000,000,000 in 1939. This increase of nearly 450 per cent was accomplished while the country's population rose only 60 per cent. In this same span of years, technological developments and improvements in methods had

the capacity of our industrial system is dependent, to a considerable extent, upon the ability and ingenuity of American design engineers. Germany's military might was successfully mechanized because Germany, for more than 10 years preceding the war, was riding the wave of a world-wide technological revolution. This revolution was as far-reaching as the advent of the electric motor and the internal combustion engine. It was born of the profusion of inventions and discoveries since the last war. German design engineers took advantage of every one of these.

If we are to defeat our enemies and if we are to continue to play the leading role in the post-war world we must make better use of the new technology than do our enemies. The job is up to American product engineers who already have made tremendous strides in designing the intricate machinery of production and of war equipment. Much remains to be done however.

It has been said that the Germans have not developed one single item that can be classified as basically original, nor are there indications that any so-called "secret weapon" will henceforth be developed by them. Today the Nazis are completely outclassed by the tremendous manpower of engineering brains that is at the disposal of American industry. Although we were faced by the same fundamental problems of shortages in materials, manpower and time, our engineers not only solved these problems quickly and effectively, but they outstripped the enemy by the preponderant weight of talent which we were able to bring to bear upon our problems. As is evidenced by studies of the designs of captured German war equipment, our airplanes are faster, carry heavier loads, have superior protective armor and heavier armament. Our tanks, especially the Shermans, stand unmatched. Our tractor-mounted artillery excels theirs in fighting power. Our automotive vehicles are the envy of the world. Our battleships are supreme. Our signal and detection devices are frustrating all of our enemies' attempts to dominate the seas.

And as we approach the end of the conflict, the pattern of which already has been set, the forces that converted American industry from peace to war-production will again be brought into play, and the product engineer will continue to be the fulcrum. Our post-war industry will grow from his blueprint. Nor will his job be any less urgent, any less responsible, any less sweeping in its effects than were his efforts during the war-preparedness program.

Since the cessation of the manufacture of peace-time goods, many new materials and production techniques have been developed. Plastics, synthetic rubber and magnesium in the field of materials were relatively new and restricted in their uses when war came. So were powder metallurgy, induction heating, electrostatic heating, adhesives for joining metals and compressed resin-impregnated wood. The new possibilities in product design created by the electronic devices and applications developed during the war period virtually stun the imagination and the "atomic revolution" promises to change the entire pattern of manufacturing operations.

Never before has there been so much speculation about the future as there is today. Looking forward, who can doubt our limitless capacity to continue our industrial world leadership?

While no one can predict developments in product design in the post-war period, certain it is that they will be so vastly different and so far superior to existing designs that they will obsolete most products as we know them today. With engines of vastly superior metals, designed to burn 100 octane gasoline and built to a precision ten times greater than that of pre-war engines, our post-war automobiles will give from 40 to 60 miles to the gallon. Tires will last from forty to fifty thousand miles. The comfort and smoothness with which these cars of tomorrow will glide along are undreamed of today. Polaroid windshields will eliminate the glare of oncoming headlights and the driver will need to give but scant attention to the manipulation of his simplified gear shifts.

According to no less an authority than Igor Sikorsky, we stand on the threshold of a new air age in which the helicopter will contribute to the greatest prosperity we have ever known.

Prophecies are hard to make at a time like this but speedy house building seems to be a certainty in the world of tomorrow. Air conditioning, new methods of heating, humidifying and drying, promise to be necessities in the post-war home. Vacuum sweepers will be much lighter, less noisy and easier to manipulate. Washing-machines will be fully automatic and practically free of noise and vibration. Not only will our homes and most of the furnishings be of radically new design, but so will the factories and machines that produce them.

Only one factor can prevent the fulfillment of the dream of the product designer. His job is not accomplished over night. To convert sound ideas into production blueprints involves a great deal of time and money. The building of test models is an expensive and tedious procedure. An abundance of seed money is required to perfect the product, to develop mass-production methods and to bring it to fruition as a finished saleable product.

It is the patriotic duty of every industrial leader to hasten these developments so that the material benefits created by them may speed our progress along the road of abundance.

President, McGraw-Hill Publishing Company, Inc.

Aviation—A Progress Report

The Lessons of War Become the Key to a Richer Peace

TUNISIA, PANTELLERIA, SICILY—stepping stones to momentous events! But that is not all. For they spell out across the blue waters of the Mediterranean a pattern of invasion that has progressed far since last summer's first major Commando operation against the French coast.

From Dieppe, you remember, too many of the raiders never got back. But in Tunisia, and on through Sicily, the Allied might plowed inexorably forward, winning objective after objective at a surprisingly low cost in casualties. Air supremacy over the battlefield? Yes. But we have learned, too, how to save lives and shorten the war by strategic air bombardment as a prelude to invasion.

Thus the bombardment plane—rarely seen by the doughboys on the fighting fronts—is destined to save their lives by hundreds of thousands in the decisive attacks that are to come. This fact is confirmed by the cold calculations of the responsible strategists. It will give renewed courage and confidence to every member of the armed forces and of the home fronts throughout the United Nations.

For instance: thorough strategic bombardment of an objective reduces by nearly fifty per cent the surface forces required for invasion. Anticipated losses are reduced from more than fifty per cent of the original ground force to about twenty per cent. Precision bombardment—as used on railroad objectives in Rome—reduces this percentage of loss still further when it is followed by offensive action on the ground.

This is the fifteenth of a series of editorials appearing monthly in all McGraw-Hill publications, reaching more than one and one-half million readers. They are dedicated to the purpose of telling the part that each industry is playing in the war effort and of informing the public on the magnificent war-production accomplishments of America's industries.

The inference is clear. Effective prosecution of the war will require smaller ground combat forces and much larger air forces than some of our strategists once thought.

Our most urgent need, then, is for ever-mounting fleets of aircraft. And, fortunately, this is just what we are getting. The American aircraft industry now is producing as many airplanes as all the rest of the world combined. In 1938 we made 100 planes a month. Now we make three times that many in a single working day. By the end of 1943, our production rate will be about 10,000 a month.

But at this stage of the war, types of planes are more important than mere numbers. In the early months the program was heavy, and properly so, with single-engine trainers. Then, as training planes accumulated, the emphasis shifted to heavier types. Now we are turning out multi-engined bombers at a rate that is the envy of the entire world. Some months ago the President revealed that we were manufacturing 500 long-range bombers every month. The figure was conservative even then. And soon we shall be producing planes of this one type at a rate adequate to replace the normal losses of a fleet of at least 1000 American heavy bombers operating as continuously as the weather will permit.

A glimpse of the poundage production may help us still further to evaluate the miraculous achievements of the aviation industry as a whole. It was 89,000,000 in 1941 . . . 291,000,000 in 1942 . . . 911,000,000 in 1943 . . . and 1,417,000,000 in 1944

increased the value added by manufacture per wage earner by 200 per cent, and the horsepower per factory worker had been multiplied by 2½. *The nation's production plant was ready to assume its gigantic wartime job.*

During this period of industrial and national evolution, management itself had changed. Prior to the advent of scientific management, our goods and services were the product of several kinds of directive activities, varying from the strictly paternalistic to the ruthless. There was little conception of the responsibility that industry now broadly acknowledges — the responsibility of trusteeship in the interest of stockholders, employees and the public — specifically; in the interest of our national economy — generally. Acceptance of this stewardship is acceptance, also, of the belief that, in the long run, no industry, and no unit of industry, that does not serve society can live.

Have the actions of management caused the times to change? Or has an alert management been successful only because it has changed with the times? Certainly, the industrial concern of 1900 would not thrive under the conditions of today. Just as certainly the new things that industry has in store for a waiting postwar world will have a far-reaching effect upon the times.

Management today seldom owns the factory or the business it manages. It is hired to perform the coordinating, directive functions. It is free to change — of itself, or with the times. Management therefore exercises its power through leadership in executing ideas . . . not through ownership.

Good management can be sustained only in an environment sympathetic to its aims. It has an undeniable obligation to society, because it must be a compatible part of the social structure or be rejected by that structure as a whole.

An environment sympathetic to its aims means, also, that industry, in the very serious reconstruction period ahead, will not be at full effectiveness if it is subjected to attacks by government no matter what the underlying reasons may be — over-zealous devotion to a cause, lack of understanding or just plain politics. It was to industry — to industrial management — that the government turned when our existence as a free nation was threatened; it is to industrial management that government must turn in order to win the peace.

This statement is made in the sincere conviction that what has made America strong is industry's ability to produce consistently more and more goods and services for more and more people. It is only by actually creating them that we built up our stockpiles of the necessities of life. And it is only by creating them that we can have more of those things that make life worth while. These become available to more people as industry succeeds in getting greater output of goods and services for a given input of human energy, materials and power.

And what of the physical jobs ahead? In this country alone, there will be an immense demand upon industry to supply the things people have been unable to purchase during the war. Today the nation is wearing out not only its automobiles, refrigerators, vacuum cleaners and radios, but its very houses, its roads, railroads, and airline equipment. It is saving its money while whetting its appetite. Truly, the calls the American people will make upon industry in the postwar period will be many and insistent.

This demand can be viewed in another light. Economists say there will be 56,000,000 persons seeking gainful employment after the war. The Committee for Economic Development has estimated that $140,000,000,000 worth of goods and services will be required each year for those people. Compare that with our actual output of $97,000,000,000 worth of goods and services in 1940 when gainful employment was 46,000,000.

These future jobs will be done if industry's management is not too much hampered by government management. Management in industry performs its function in the field of doing things. Management in government performs its function in the field of *regulating* things. The best cooperation of the two kinds of management will be necessary in the postwar period. Certainly, too much of the regulatory kind will interfere seriously with the kind that does things.

Industrial management must improve, too. If it is too selfish, if it does not recognize definitely the trusteeship inherent in its job, if it does not understand and live up to its social responsibilities, then it will be risking all for which we are fighting. The following suggestions are made to indicate the direction that management's self-improvement can take.

Evolution in management has been too slow in some respects. Management in industry has been too prone to see the advantages in technological development while being blind to its evils. Looking at industry and social progress as a whole, there can be no doubt as to the value of technological improvement. It creates jobs. It elevates the standard of living. But that economic fact is of no satisfaction to the individual who loses his job because a new machine or a new method required one less man. By and large, this is an evil that management can do something about.

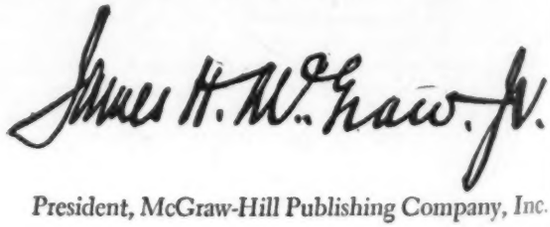
Management has been too careless of its opportunities with regard to labor. On that account the pendulum of social readjustment has swung too far. Labor has been given extensive privilege without corresponding responsibility.

Industrial management has been too slow to abandon its policy of letting the buyer beware. As a result of this, industry today is over-regulated.

Management has been too slow in recognizing its responsibility to promote the economic philosophy that a society cannot have for consumption what it does not produce. A companion educational item too long neglected is management's obligation in the field of public relations.

In these years since 1900, industrial management has been growing. Perhaps many of its experiences have been but growing pains. Management has learned, among other things, the absolutely vital need for capital at the right time and in the right amount. It has learned to use some of its earnings as "seed-money" in the introduction of new products and the use of new processes. It has learned to invest more and more in research. It has learned of the interdependence of industry and agriculture. And it has learned much about the eternal triangle of industry, labor and government.

With such a history and such experiences behind it, I have every faith that management is going ahead to even more glorious accomplishments in the winning of the war, and I believe that its peacetime accomplishments to come are beyond the prediction of any of us — even management itself.



President, McGraw-Hill Publishing Company, Inc.

This is the fourteenth of a series of editorials appearing monthly in all McGraw-Hill publications, reaching more than one and one-half million readers. They are dedicated to the purpose of telling the part that each industry is playing in the war effort and of informing the public on the magnificent war-production accomplishments of America's industries.

– if we need it. There you have the magnificent record of the American aircraft manufacturing industry – a monument to the cooperation of industry, labor, government, and to all-out teamwork between the aviation industry and those other industries which have converted their facilities to the manufacture of airplanes.

What of our enemies and our Allies?

German production probably has flattened out at 2500 a month – with downward revision in immediate prospect. Japan may be able to produce as many as 1000 planes a month – until we get our new long-range super-bombers in sufficient numbers to whittle down that figure. Italy may be able to turn out her 500 a month – for a little longer. At best the maximum Axis monthly total is 4000.

Add to our monthly score of nearly 8000, a total of approximately 4000 for Britain, Canada and Russia, and the United Nations score comes to 12,000 monthly. There we have a three to one advantage for our side. And between our own rising production and the brilliant operations of our bomber commands we should soon boost the ratio well above that figure. Therein lies the certainty of continued and growing air superiority over all the far-flung battlefields.

The critics of American airplane quality have been silenced ever since the ratio of enemy combat losses to our own on bombardment missions surpassed four to one. In the Pacific where our heavily armed and armored planes are knocking off the desperately stripped racing craft of the Nipponese, enemy losses often run as high as eight to one or more. In the Mediterranean theater, where the Italians were abandoned by their Allies, the story is much the same. Only in the well-defended homeland of the Nazis do we sometimes drop below the average, but even in those rare instances the ratio is still well in our favor and the effectiveness of our bombardment is adding constantly to our margin.

* * *

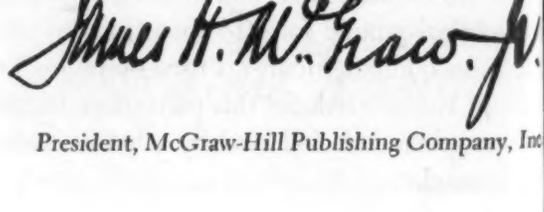
Behind the production lines the battle of research and design still rages. In many a laboratory night-shift, on many a secret test field, new and terrible surprises for the enemy are in the making. Super-bombers, destined for Tokyo, have long since passed out of the design stage and the Japanese may learn about them almost any day. New discoveries, designed to sow swift and silent devastation, are farther along than our enemies believe. No longer will fog or storm or night be permitted to fight on the side of our foes.

The men of science who are toiling to broaden the horizon of our knowledge stand today on the threshold of discoveries that have been sought for centuries. New reservoirs of power may soon exert a profound influence in many fields of technology and through them on our way of life.

Once the war is won these new discoveries will be translated into better living. No longer will countless thousands spend their lives within their own communities or countries. New efficiencies in transportation will bring world travel within the reach of many who once had to stay at home. New family vehicles will navigate the skyways as easily and safely as the highways. Already more than a dozen manufacturers of airplanes, ships, automobiles, and electrical equipment are designing, building, or flying rotary-winged aircraft such as the helicopter or autogyro to meet the needs of tomorrow's families. New and safer aircraft of the fixed-wing type are ready for production as soon as materials become available.

The quality that now makes each of our war planes worth so many of those built by our enemies will be translated into the sturdy reliability demanded by peacetime operation. The devices that seek out and find our enemies behind the veil of fog or darkness will, after the war, reduce weather hazards to the point where they will be no greater in the air than on the ground.

Science and industry will continue to do their jobs and do them well. But if the world is to be made a better place for men to live in, statesmanship must not fail to do its part.



President, McGraw-Hill Publishing Company, Inc

Free Enterprise

WE MUST ACT TO PRESERVE IT!

☆

LIKE a leaf floating downstream, we are being carried along toward a new and uncharted economy. What this new economy will be like will depend, to no small extent, upon what industry does or fails to do during the coming months. Time is short; in fact, we may suddenly find ourselves standing on the threshold of a peace economy with our war boots still on our feet.

While bending every effort to win the war, we cannot afford to be caught unprepared for the peace. As Prime Minister Churchill said at Harvard, we are "bound, so far as life and strength allow and without prejudice to our dominating military task, to look ahead to those days which will surely come, when we shall have finally beaten down Satan under our feet and find ourselves with other great Allies at once the masters and the servants of the future." Unless we do look ahead, there is danger that we may become neither the masters nor the servants, but merely the victims, of the future.

The war has quickened our ailing economy and opened our eyes again to the possibilities of peace-time plenty. But it has also brought great dislocations of labor and capital; it has led to abnormal patterns in prices and income distribution; and it has created inflationary pressures with enormous potential powers to injure or to help us in the transition from war to peace.

The pattern of life in postwar America will be just what we make it. All of us will have a hand in shaping that pattern, but business men will have a special responsibility in the reconstruction. As employers of labor and capital and as enterprisers assuming the risks of new ventures, they will have to plan and carry out the conversion from war work to full peace-time production. Because of their key role, business men have a special opportunity to discover, and to help others to understand, the conditions which are necessary if they are to do their job satisfactorily.

This is a narrow view of postwar problems but it is a central view, because no one condition is more vital to the health of the world than a high level of production and employment in the United States. We cannot hope to lead the world out of economic chaos if we fail to put our own house in order. If we fail to adjust our domestic economy, we may destroy Adolf Hitler; but we will not destroy the germ that breeds "Hitlers." If we do not maintain the production necessary for supporting a large volume of imports and exports, then the plans for international monetary stabilization, for good relations with our neighbors, for rehabilitation of stricken countries, and for strengthening the democratic bulwarks against dictatorship are all likely to come to grief. We must demonstrate our capacity for world leadership, or be content to follow the leadership of others.

The prospects for achieving a sound and vigorous economy in the United States are not so good as to warrant complacency on the part of men genuinely interested in free enterprise and the political freedoms incident to it. We have yet to find means to utilize our vast and abundant resources for the good of all. We have yet to learn how to keep men from the terrible experience of unemployment and the fear of want which makes them willing to sacrifice freedom and opportunity for almost any promise of security. We have yet to reconcile the conflicting interests of labor, agriculture, and business so that they can work together effectively. We have yet to learn how to check the fever of inflation and cure the palsy of depression.

When we were attacked at Pearl Harbor, we realized our physical peril immediately and united in a tremendous common effort against the enemy. The onset of economic perils is less obvious. No bombs will signal the deterioration of the private enterprise system, the extension of regimentation, the further control of busi-

ness by government, and the concentration of political power in less and less responsible hands. If these things should befall us, they will come insidiously while we are preoccupied with self interests and oriented by popular misconceptions. If the freedoms of the individual shrivel as the state grows in power, it will be because the individual is too indifferent or complacent to concern himself seriously with economic problems. If our people are misled by false prophets and demagogues, it will be because business men did not understand economics, because scholars were too ignorant of practical affairs, and because we failed to produce economic statesmen of sufficient stature for the task in hand.

Thinking is hard work. Thinking about things outside our personal experience, about economic processes that are broader and in some fundamental respects different from buying and selling or running a business – is strenuous mental labor. Thinking straight about problems that are beyond our personal and immediate status and our pocketbooks, thinking about problems that involve nation-wide production, nation-wide employment and nation-wide buying power – in other words the operation of our entire economic system – involves real self-discipline. Yet there is no other way to safeguard our freedoms. We cannot rely on trial and error; tinkering takes too long; social experiments which turn out wrong can be undone only at great cost – if at all. If we proceed blindly, we shall flounder into an economic and political morass from which we cannot escape.

We floundered badly all through the Thirties, until the war lifted us temporarily to higher ground. When the war boom is over, we shall be back floundering worse than ever unless we find a solid road along which to proceed.

America has grown rich and strong under a system of political and economic freedom. Opportunity and the necessity of self-reliance have brought forth great accomplishments. The hope of profit and the spur of competition have urged men on to find new and better products, new and better methods, and to risk their savings in pioneer investment. Never has a country achieved so high a standard of living and afforded so large an opportunity for the individual man and woman. It is not surprising that some distinguished business leaders, looking back over their own experience, tell us that everything will be all right if only there is "less government in business."

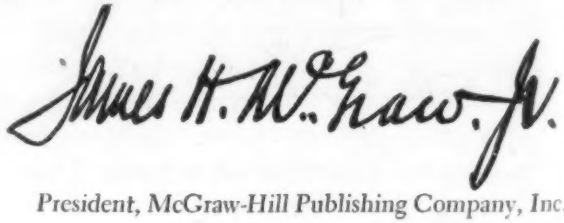
I wish the solution were as simple as that. However this is only part of the answer. It is becoming increasingly clear that industrial capitalism as we know it contains within itself certain fundamental weaknesses which can lead to its destruction if they are not counteracted. No democracy can survive when twenty to thirty per cent of its workers cannot get jobs. That happened here in the Thirties. For years on end, despite fumbling efforts at recovery one out of every five workers was denied a chance to earn a living in private business. We shall never again have such mass unemployment as occurred in the bottom of the Depression, because the government will take it upon itself to create jobs if business cannot offer them. Whenever that happens, however, the area of private enterprise will be reduced and that of government will be expanded – and the concentration of political power will be increased. This is the challenge we business men face today, and ours is the first opportunity at finding the solution.

The crux of our economic problem is unemployment. Unless there are jobs for ninety to ninety-five per cent of those who are able and willing to work, there will be widespread fear and lack of opportunity, which will drive labor unions, agricultural groups, and business interests to take self-protective measures. Such measures are certain to restrict production, stifle progress, and imperil our democratic way of life. Not all our problems will automatically be solved if we learn how to avoid mass unemployment, but they will at least then have a good chance of solution.

And so American businessmen face a great responsibility! We will have to find the answer to a great many momentous questions. We will have to delve into problems that cannot be solved by precedent.

Looking backward to these times, future historians are likely to say that here we Americans stood at the crossroads and, consciously or not, made our choice between a system of private enterprise and personal freedom and a system of collectivism and regimentation.

It is particularly appropriate, therefore, as the problems of our time take shape and as events rearrange their order and importance, to appraise the steps we are taking and point the way we are going. It is my plan to present such analyses from time to time to the one-and-a-half million readers of McGraw-Hill publications.



President, McGraw-Hill Publishing Company, Inc.

Free Enterprise

WHAT IS IT? HOW DOES IT WORK?

☆

Ours is a free-enterprise economy the chief motivating forces of which are the prospective rewards for effort and risk-taking. Its smooth operation depends: first, on adequate incentives for risk-taking, innovation, and individual effort; and second, on sufficient competition to minimize the need for government regulation and to prevent artificially high prices or wages from being maintained in large segments of the economy. Trouble comes when these incentives and this competition are tampered with or removed.

America was founded by men who had the urge to better themselves and the courage to take a chance. These men uprooted themselves in Europe and braved the unknown. They risked all for freedom. They knew that, to be free, they had to attain economic freedom. Their goal was an economic freedom which permits the private ownership of property, the free choice of jobs, and free entry into entrepreneurial pursuits. Their efforts, therefore, were directed toward individual opportunity with no limit on individual achievement. Their foresight and the endeavors of those who followed them created the world's greatest industrial nation enjoying the highest standards of living.

We can take pride in the knowledge that our country has been the greatest single contributor to the world's physical assets even though we remember that an abundance of natural resources contributed materially to America's economic development. But the fact that our progress has been interrupted, again and again, by depressions which resulted in enormous wastes of our human and material resources is sobering proof that our economic mechanism still is far from perfect.

Our production per man-hour has been increasing at the rate of 2½% per year. Improved machines and greater efficiency have more than tripled the output per hour of work since 1900. Looking to the future, this annual rise indicates that our production per hour of work will double in the course of the next 25 to 30 years. This means that we can have twice our present volume of goods and services per capita or an equivalent combination of more production and more leisure. In other words, we can further increase the living standards and further decrease the working hours of the American people by further intensifying our industrial efficiency.

This is no idle dream. It can be achieved, and it will be achieved, if only we maintain the essential features of our system of individual enterprise which alone makes possible this near-utopian goal. Intensification of our efficiency, however, means that we can have full employment only if we expand enormously our production, and particularly our production of new goods. We can expand total production only if we have the markets and the demands for the vast output of goods and services made possible by our technological development. To attain these, we will need to venture into new markets, new inventions, and new methods. Such ventures involve risks, and risks will be taken only if there is sufficient prospect of reward.

Let us never lose sight of the fact that the essential features of free enterprise are the prospective rewards for risk-taking as well as for effort.

The evidence is clear that incentive methods of wage payments will boost production. Carefully devised systems of salary payment with large differential inducements for superior performance have been powerful means of raising the standards of managerial accomplishment.

Free enterprise cannot operate effectively unless the wage and salary system offers greater rewards for greater effort. Neither can it operate effectively unless the prospects for profit are sufficient to encourage the employment of resources which otherwise would be kept idle.

Unless the prospects of profit are superior to the prospects of loss, new ventures will not be undertaken and going concerns will not expand or continue long in business. When the hope for profits wanes, employment and production slump; when that hope revives, employment and production recover.

Business initiative must be given every possible in-

ducement in order that maximum employment may be achieved through private enterprise. This involves the removal and avoidance of restrictions on business by government, by labor, and by business itself.

Competition is the life-blood of the free enterprise system. Business and industry must rely upon efficiency rather than upon protection from competition for their survival.

Those government controls which were made necessary during the war by the magnitude of government demands for goods should be lifted at the earliest possible moment. As soon as the danger of inflation has receded, price controls must be removed and profit margins again left free to be determined by market forces. The excess profits tax must be repealed and the burden of other taxes on business profits greatly reduced. Tax laws should be revised so as to permit adequate rewards for assuming risks. The modernizing of anti-trust laws and their vigorous enforcement, not indiscriminate persecution, will be supported by all who really want free enterprise. Such measures will strengthen the incentives to expand old businesses and to start new ventures.

Grants of unlimited monopoly powers to labor unions which enable them, consciously or not, to sabotage the profit incentive in business must be withdrawn. Labor has certain legitimate rights; and in order to preserve them and its freedom, labor must come to realize that its best interests lie in a well functioning, self-disciplined competitive free-enterprise economy.

There must be evolved in the minds of business, labor, and the public a recognition of the need for private business enterprise and a realization that policies which throttle it are harmful not only to businessmen but to workers and consumers as well. Unless we achieve this understanding and avoid needless deterrents to business expansion, we are likely to pay for our folly in the destruction of our free enterprise system.

We cannot tolerate conditions in which special interest groups in business, labor, agriculture, or politics prevent free access to the market by would-be competitors. Such monopolizing of opportunities stifles progress and creates profits or wage rates based on artificial scarcity. In such cases government interference to open the market to all comers is clearly indicated. We must recognize the need for constructive policies by business, labor, and government which will insure the competition necessary for the successful operation of our economy.

Increased government regulation and control of business activities is not conducive to strengthening the virility of private enterprise. Government ownership and operation of productive resources certainly is not to be condoned. The more government rules and regulates business, the less will be the incentive to assume risks and to exercise individual initiative. Government regulation of the detailed operation of industry inhibits progress, is prey to political pressures, and is subject to the human failings of its administrators. *Better far the rough guidance and justice of vigorous, though somewhat imperfect, competition than the uncertainty of arbitrary regulation.*

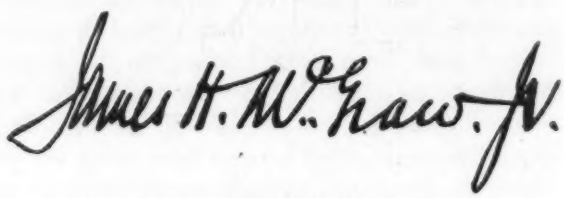
The gravest threats to our competitive system exist in legalized monopolies, such as the N.R.A. once comprised, such as the labor unions and farm groups have recently achieved, such as businessmen themselves have sometimes sought. The power of labor monopolies to encroach on business profits will tend to interfere seriously with the needed flow of new investment. And when any group is strong enough to move the average level of costs as much as the labor groups and the farm groups are able to do, there is good reason to fear that, when we begin to approach high levels of employment and production in time of peace, these groups will induce a price-wage spiral which will waste money incomes on price increases instead of permitting them to draw unemployed resources into production. While the demands of labor for collective bargaining rights and the demands of farmers for protection against the rigors of depression have validity, there can be no reason for excessive grants of power and privilege which threaten to make our system of free enterprise unworkable.

Ours is a complex economic structure. The functions which prices, income, savings, investments, and taxes play in this system are difficult to comprehend.

As I have said before: Thinking is hard work, and we will have to work hard if we are to develop business policies, labor policies, and government policies which will insure full employment and the opportunity for consistent profit. Yet only through such policies can we guarantee that private enterprise will be the predominant source of jobs, income, and production.

Even more difficult than thinking, and more important, is the implementation of many policies that are in the interest of the free enterprise system. Not all measures will satisfy all people. Special interests will have to be subordinated to the total interests of the nation. Sacrifice and vision have been essential to the winning of the war. They will be no less essential to the winning of the peace.

If we can gain recognition of the crucial role of incentives for enterprise, if we stand squarely for competition and against protection or privilege for special interests, and if we bend our efforts to find satisfactory ways and means to prevent large-scale unemployment, we can have the full benefits which only a free enterprise system can produce—in industrial progress, in improved standards of living, and in the preservation of our democratic ways of life.



President, McGraw-Hill Publishing Company, Inc.

Free Enterprise

THE OPPORTUNITY AND OBLIGATION TO COMPETE

WE can be prosperous beyond our dreams—all of us—workers, farmers, and business men—but one of the prerequisites is the self-discipline of accepting competition for ourselves as well as others.

* * *

Free enterprise does not imply the freedom to use any or all means to make a profit. It does not mean the right to monopolize. ***It means the opportunity and obligation to compete.***

Competition requires ***independence of action, free access to the market,*** and ***no large degree of control over the price*** by any buyer or seller. In general, the larger the number of sellers and the more easily buyers can shift from one seller to another, the higher will be the degree of competition (and vice versa for buyers).

But let us not get too academic or go off the deep end. We cannot have perfect competition. We cannot subdivide businesses and labor unions into tiny units to make a multitude of buyers and sellers in each market; we cannot reduce our rich variety of products to a few rigidly standardized items; we cannot educate people to judge quality precisely; we cannot eliminate the costs of bridging space between buyers and sellers. On the other hand, have we gone as far as is practical and desirable in these directions?

We cannot even have a system of highly "sensitive" prices, that is, prices which fluctuate immediately in response to every minor change in demand and supply. This would occur in the dream world of competition-to-the-nth-degree. It cannot occur in the real world, or even in the ideal world of competition best suited to physical facts and human qualities. The economies of large-scale enterprise, the need for adapting products to human wants, the costs of transportation and the costs of issuing and acquiring market information put severe limits on price sensitivity.

Economists tell us that if prices were extremely sensitive, business booms and depressions would be much less severe—provided our stock of money remained fairly constant. But with the somewhat limited degree of sensitivity which is practicable in the economy, price and wage changes cannot prevent severe declines in business activity. ***We cannot count on competition alone to cure depressions.*** We must look mainly to other kinds of measures to prevent mass unemployment of men and machines.

If we cannot have prices which fluctuate with every small change in demand and supply conditions, we can work toward—and achieve, if we really want it—a system in which prices and wages are at least roughly responsive to long-run changes in demand and supply, a system in which most markets are not dominated by individual businesses, groups of businesses, labor unions, or farm organizations, and in which prices and wages are maintained at levels consistent with free access to markets and to jobs.

In any kind of an economic system there must be some means of determining prices, wages, and profits, and of bringing labor and capital into employment in the industry and place where they are most needed. There are two ways to do this: by administrative fiat or by the impersonal processes of the market. The first of these is typical of the totalitarian state; it frequently involves destruction of individual freedom or fumbling mismanagement. During the war all of us have had some experience with patronizing and paternalistic treatment by the state; we have found out what it means to be pushed around by bureaucrats; and we have discovered that the political determination of prices, wages, and profits leads to chaos when self-interest supersedes the fine fever of patriotism—as it eventually does. I do not mean to imply that we can do without controls over prices, production, and distribution in time of war; but I do suggest that we can learn something from their operation. Even with a united national purpose these controls work badly when human abilities are inadequate for the superhuman task, when personal or departmental jealousies crop up among officials, and when pressure groups try to prey on the rest of the public. Every day more Americans are beginning to understand why our forefathers feared the caprice and tyranny of power.

The impersonal processes of the market in determining prices and wages and in allocating productive resources will, in normal times, save us from the fumbling of bureaucrats and from the Babel of confusion, un-

certainty, and annoyance produced by their regulations. But these market processes will not save us from paying toll to those who monopolize and restrict entry to markets or jobs.

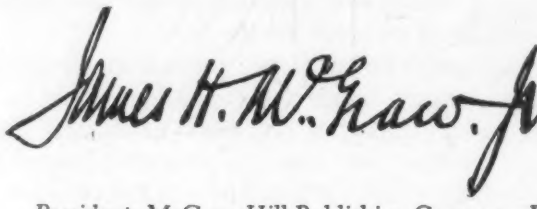
If we want an economy in which we are free to try out new ideas, develop new products, and introduce more efficient methods of production, if we want an economy in which there are great opportunities for men of imagination, inventiveness and energy, if we want an economy wide open to progress, then we must have a free field and fair competition for all comers—without collusion as to prices, markets, or production. This is the only basis on which we have a right to demand freedom from governmental regulation for ourselves and on which we can combat monopolistic tendencies in other quarters.

Let us stand squarely for the principles of the anti-trust laws and against all collusion and combination in restraint of trade. Let us insist that the government review with a critical eye every combination and consolidation which might restrict competition. Let us face frankly the problems of economic power arising out of price leadership and encourage every honest effort to find means to deal with them. Let us not shrink from questions as to whether some great aggregations of plants are too large for efficiency, free entry into the industry, and a free price. While we resist the efforts of the Department of Justice to extend the anti-trust laws by far-fetched and distorted interpretation, and while we fight every attempt to use them as a tool of persecution, let us cooperate in sincere efforts to modernize these laws and extend them by specific legislation to monopolistic practices they cannot now reach. I do not have a simple formula for this, but I believe we must try to find one.

We can then, better face the problem of the growing monopoly in labor which is threatening to make the free enterprise system unworkable. Today labor is going through a stage of empire building reminiscent in some ways of a similar stage in business three-quarters of a century ago. Witness the same buccaneering spirit, the same concentration on selfish interests, and the same disregard for the public welfare. Business leaders learned the hard way that the public will eventually rise up against those who prey upon them. Will our labor leaders be wiser? The right to collective bargaining to protect the weak position of the individual employee is one thing—but the grant of unlimited monopoly privilege to combine into a private government which can dictate its own terms to businesses, industries, communities, and even to the government itself, and which can start a wage-price spiral such as to hinder the war effort and make full prosperity impossible in time of peace is something quite different. We need to find a middle way which will prevent employers from exploiting employees but which does not sow the dragon's teeth. The exercise of arbitrary power by labor threatens not only business, but also all workers outside the unions and all those dependent on pensions and savings for their existence, and ultimately, of course, the well being of union workers themselves.

The idea that the labor problem can be solved if great, powerful organizations of employers will sit down with great, powerful organizations of labor is a delusion. If our experience in the N.R.A. and in the war teaches us anything, it is that the best that can be expected in the long run from such a situation is an armed truce with intermittent civil war. And every truce would be a monopolistic arrangement to take advantage of those not members of the great organized groups. Business and labor unions, whenever confronted with postwar readjustments that are unfavorable to them will be sorely tempted to protect their own special interests at the expense of the public. There will be efforts on the part of businesses, abetted by labor unions, to limit productive capacity, to raise tariffs, to obtain subsidies, and to maintain prices at artificially high levels. The unions will oppose labor saving changes and will seek higher wages even in areas and industries of surplus labor. Already demands are emerging for direct joint action by business, labor, and agriculture to solve the transition problems of special concern to them. While these groups should have every opportunity to register their own self-interest, we cannot entrust our fate to decisions made by pressure groups. If experience is any guide, such coalitions will be almost certain to restrict opportunities for progress and expansion, to exploit the public, and ultimately to injure even the businesses, workers, and farmers included in them. We cannot afford a postwar N.R.A. Resort to temporary government regulation in the transition from war to peace may, however, be necessary in cases of great hardship.

We can be prosperous beyond our dreams—all of us—workers, farmers, and business men—but one of the prerequisites is the self-discipline of accepting competition for ourselves as well as others.



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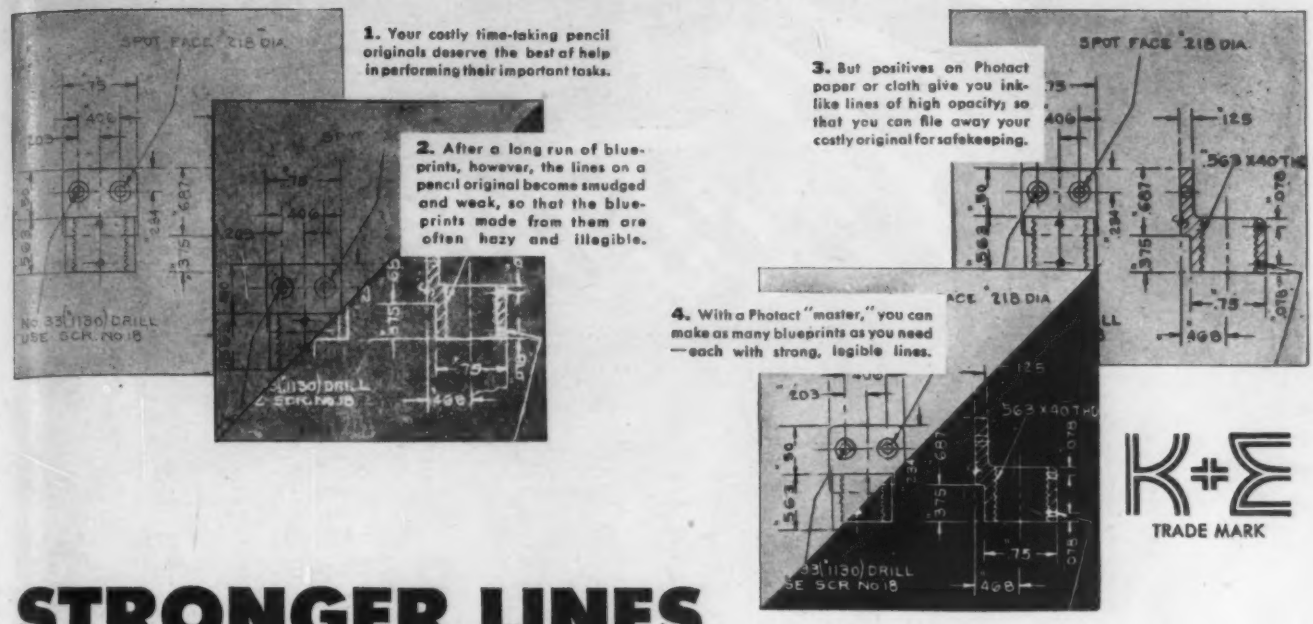
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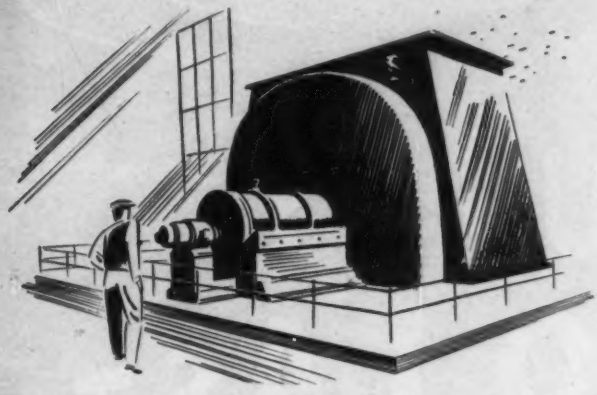
Electronics

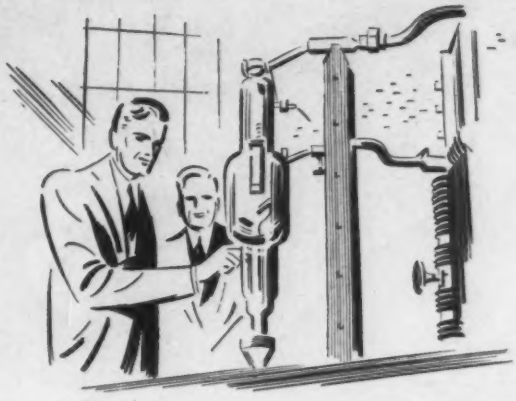
Power Line Carrier—an electronic application widely used by power companies, has greatly increased the reliability and capacity of power transmission lines, while saving critical materials. High-frequency waves, similar to radio waves, are transmitted *along the power line* instead of radiating into space. These waves, or carrier currents, may be used for reliable voice communication between remote points on a power system—or for instantaneous and automatic operation of protective devices at distant points in case of a fault on the line. They also serve as channels for transmitting metering information from one point to another automatically.

. . . at Work

To industrial men, electronics has become a versatile working tool—speeding production, improving product quality, increasing efficiency—on a thousand wartime production fronts. Here are some of the practical ways Westinghouse engineers are putting electronics to work.

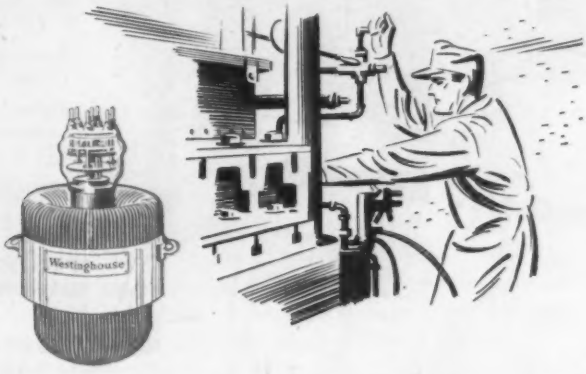


The World's Largest Induction Motor drives two 54-ton propellers at the Army's Wright Field wind tunnel. Its speed must be held constant at a preset value while test readings are being taken. Electronic regulators perform the job—holding speed "on the nose".



Millionth-of-a-Second X-Rays now enable engineers to detect flaws in inch-thick steel armor plate—photograph bullets in their flight through a gun barrel. By means of the ultra high-speed x-ray tube, weapons are constantly being made stronger, more efficient.

Protecting Workers Against Injury—On hazardous machines, such as punch presses and shears, a beam of light is projected across the machine to a phototube. As long as the operator's hand is in the danger area, the machine is prevented from operating.



In the Molding of Plastics, electronic high-frequency dielectric heating is finding wide application. By providing rapid and readily controlled rates of heating, it makes possible faster rates of processing, more uniform and better products.

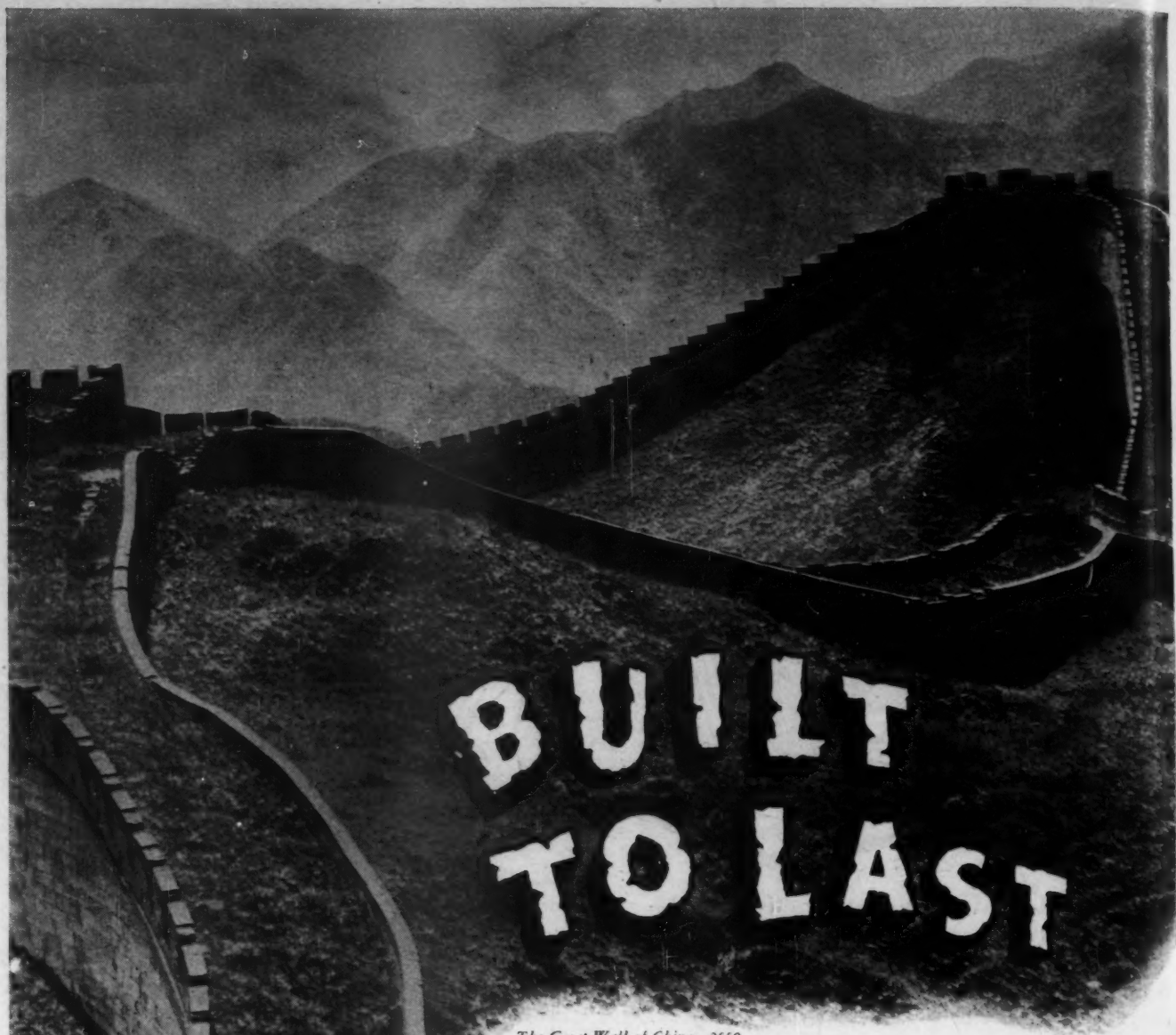
J-91034

For further information on Westinghouse Electronic devices, write for Booklet B-3264. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

WESTINGHOUSE

Westinghouse ELECTRONICS

PLANTS IN 25 CITIES... OFFICES EVERYWHERE



The Great Wall of China—2550 miles long—built about 3000 B.C.

THROUGHOUT EVERY STEP of manufacture, long life is built into Tobe Capacitors. And before manufacture begins, Tobe engineers have shown great ingenuity in pioneering new and advanced designs. The original capacitor with hold-down bracket (Tobe OM-601) is shown below. It has many outstanding advantages over certain other types and shapes of capacitors. This new capacitor is strong, compact and space-saving and the new hold-down bracket permits the use of either inverted or upright terminals, with wiring underneath or on top of chassis. Write us about your capacitor problems. They will have the best efforts of Tobe engineers.

LONG LIFE ASSURED

This new separate mounting is stronger and helps prevent leaks caused by breaks in can. This outstanding Tobe design takes the minimum amount of space.

SPECIFICATIONS
TOBE OM-601 CAPACITORS

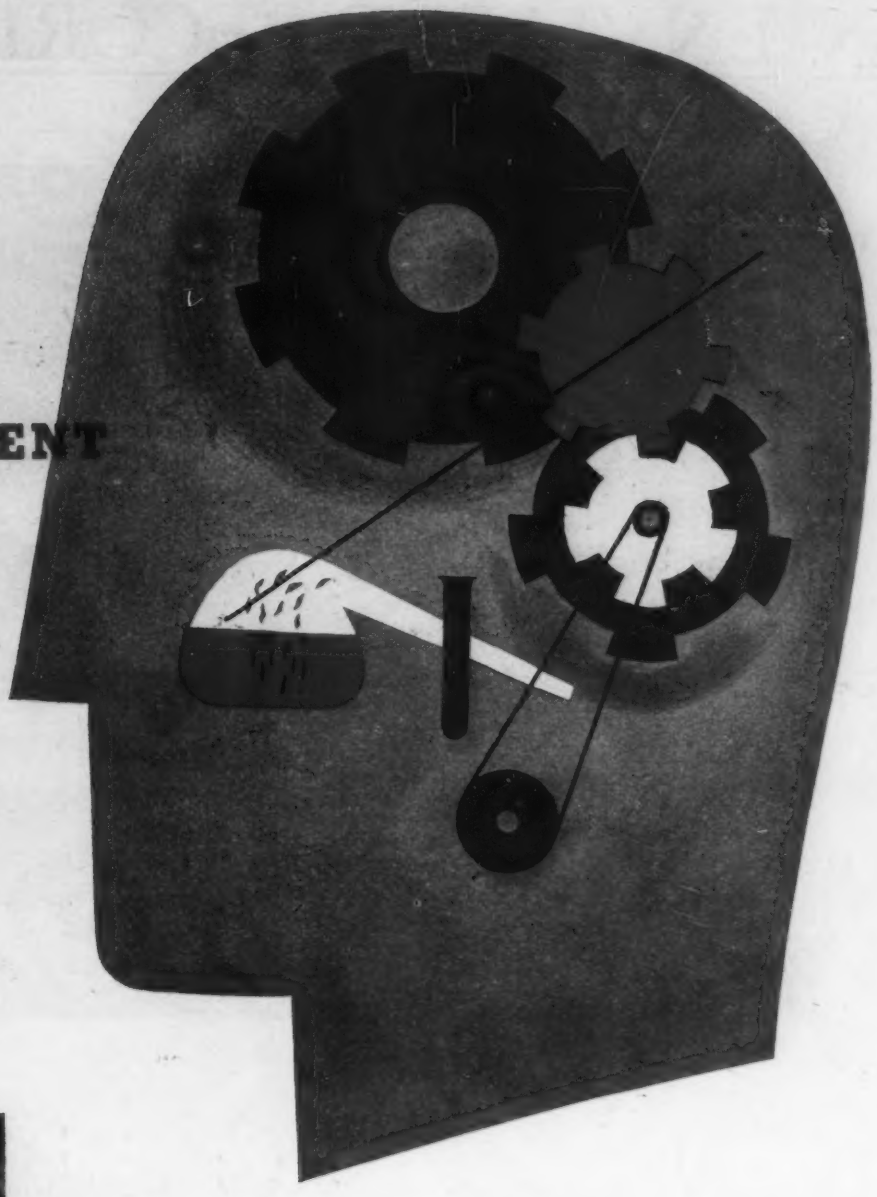
TYPE	OM
RATINGS	.05 to 2.0 mfd. 600 V.D.C. .05 mfd. to 1.0 mfd. 1,000 V.D.C.
STANDARD CAPACITY TOLERANCE	. . . 10%
TEST VOLTAGE	. . . Twice D.C. rating
GROUND TEST	. . . 2,500 Volts, D.C.
OPERATING TEMPERATURE	55° F to 185° F
SHUNT RESISTANCE	.05 to 0.1 mfd. 20,000 megohms. .25 to 0.5 mfd. 12,000 megohms. 1.0 to 2.0 mfd. 12,000 megohms.
POWER FACTOR	At 1,000 cycles—.002 to .005
CONTAINER SIZE	Width 5/8", length 1 5/16", ht. 2 1/4"
MOUNTING HOLE CENTERS	1 1/2"

TOBE DEUTSCHMANN CORP. TOBE CANTON · MASSACHUSETTS

A small part in victory today

A BIG PART IN INDUSTRY TOMORROW

TAYLOR TALENT



ARC CHAMBER PARTITION

The orthodox way to manufacture the arc chamber partition, shown above in actual size, is to slice it from a rectangular, vulcanized fibre tube. Taylor forms it from a *sheet*—at a great saving in cost. Whatever your problem may be, if you think Laminated Plastics might help you to solve it, the smartest move you can make is to Take it to Taylor.

In the production of laminated plastics, the same raw materials are available to all manufacturers. The difference in the quality of the finished product arises out of the skill, the know-how, the talent of the manufacturer. His brains and equipment are the variable factors.

Here at Taylor, in the industry's most modern plant, Vulcanized and Phenol Fibre are made by the Verifibre Process—Taylor's name for quality control. Here, too, skill and inventiveness combine to improve manufacturing processes and simplify production, resulting in better products, more economically produced. The arc chamber partition, illustrated at the left, is a typical example of Taylor talent.

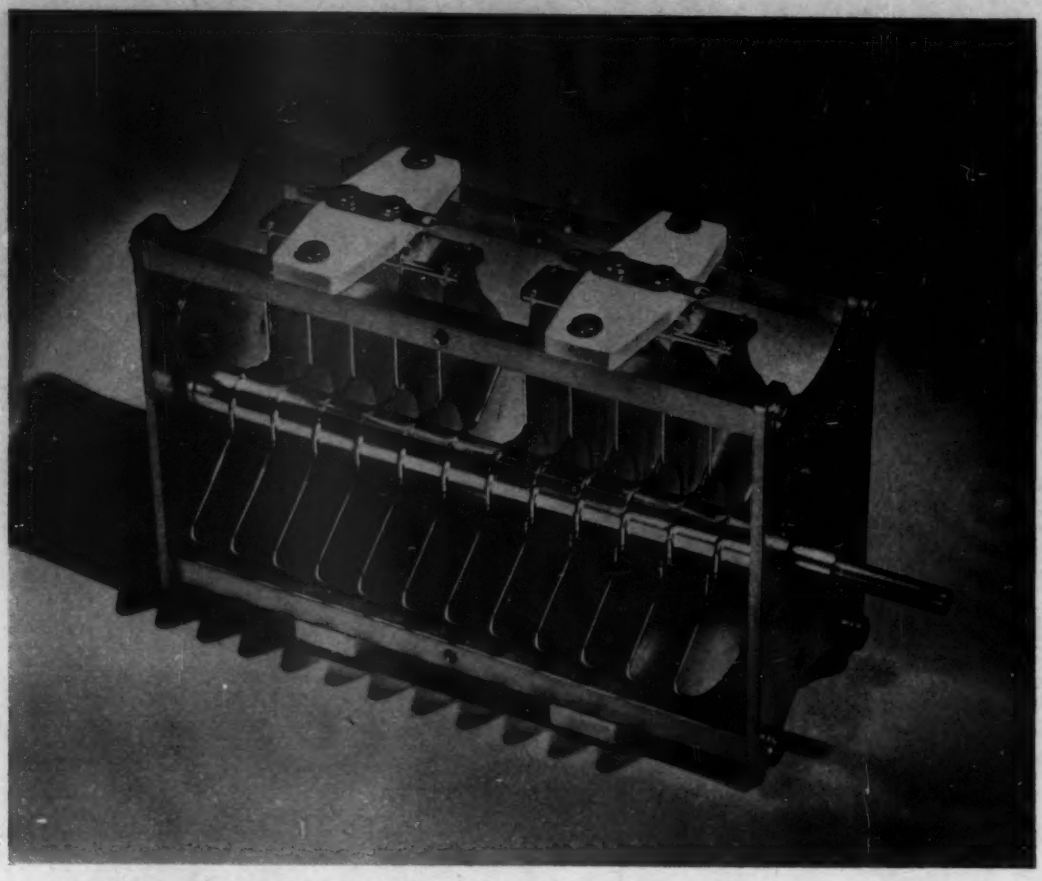
Present restrictions by WPB require that Vulcanized Fibre and Phenol Fibre be sold only under allocation. But if you have a product that's vital to the war, or if you are now doing post-war planning, our engineers will be glad to discuss your problems with you and to make specific recommendations.

TAYLOR FIBRE COMPANY

NORRISTOWN, PENNSYLVANIA
OFFICES IN PRINCIPAL CITIES
PACIFIC COAST HEADQUARTERS: 544 S. SAN PEDRO ST., LOS ANGELES

LAMINATED PLASTICS: VULCANIZED FIBRE • PHENOL FIBRE
SHEETS, RODS, TUBES, AND FABRICATED PARTS

AN ENVIABLE RECORD



Hammarlund condensers like this are serving on all war fronts.

IN tanks, planes, ships, "walkie-talkies" — wherever mechanical and electrical characteristics must remain true under the most unusual conditions—there you will find Hammarlund variable condensers adding to their already enviable record of performance.

THE HAMMARLUND MANUFACTURING CO., INC.
460 West 34th Street, New York, N. Y.

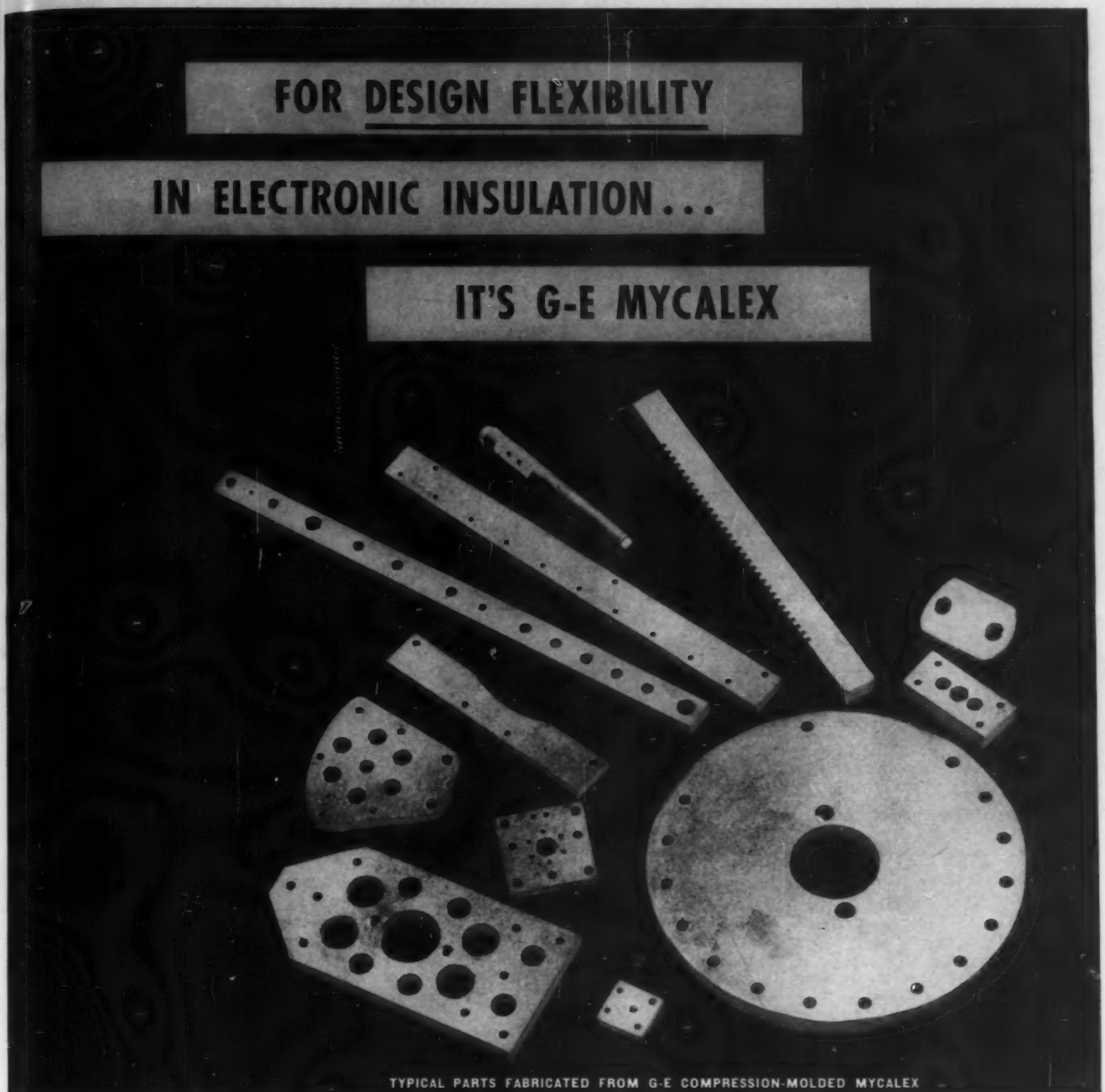
THE SIGN OF QUALITY IN RADIO

HAMMARLUND

FOR DESIGN FLEXIBILITY

IN ELECTRONIC INSULATION . . .

IT'S G-E MYCALEX



TYPICAL PARTS FABRICATED FROM G-E COMPRESSION-MOLDED MYCALEX

You can design with greater freedom when you use G-E mycalex for electronic insulation . . . because this dependable mica ceramic is unique in adapting itself to all the usual machining operations such as drilling, filing, sawing and polishing.

Strength? G-E mycalex has a uniform strength guaranteed to withstand a stress of 14,000 lbs.!

Ideal for the toughest high-frequency insulating and structural work, G-E mycalex has superior refractory qualities, high dielectric strength and exceptional uniformity, both mechanically and electrically. Its stability permits closely held tolerances. You don't have to make allowances for any more than normal safety factors. G-E mycalex is designed for *accurate* work!

G-E mycalex has had more than 21 years of experience in solving the toughest insulation problems. Let G.E.'s unequaled experience in electronics help you—no matter what your electronic insulation problem may be. Write for free sample and data bulletin, "G-E Compression-Molded Mycalex." Address: *Electronics Dept., General Electric, Schenectady, N. Y.*

• *Tune in General Electric's* "The World Today" *and hear the news from the men who see it happen, every evening except Sunday at 6:45 E.W.T. over CBS. On Sunday evening listen to the G-E* "All Girl Orchestra" *at 10 E.W.T. over NBC.*

ELECTRONICS DEPARTMENT
GENERAL ELECTRIC CO., Schenectady, N. Y.

Please send, without obligation to me, free sample of G-E mycalex and the data bulletin, "G-E Compression-Molded Mycalex."

*Name*_____

*Address*_____

*Company*_____

OVER 21 YEARS OF MYCALEX EXPERIENCE

GENERAL ELECTRIC

177-M-B3-9915

NOW 3 TYPES OF TO FIT

1

Comparative Analysis of 3 Corning Coil Form Methods

	MULTIFORM COIL FORMS	BLOWN COIL FORMS	PRECISION GROUND COIL FORMS
O. D. Diameters	9/16" to 12"	1" to 3"	¼" to 1½"
Lengths	0.70" to 10½"	2½" to 9"	½" to 6"
Wall Thickness	3/32" to ⅞"	⅛" to ⅜"	3/64" to 3/16"
Maximum Threads per inch	32	12	24
Tolerance	± 2% but not less than ± 0.010" on all dimensions	± 0.015" on root diameter of thread	± 0.002" on root diameter of thread
Holes	Mold formed	Punched or ground	Punched or ground
Metallizing	Yes	Yes	Yes
Types of Glass	No. 790 Only	No. 707 or No. 774	No. 707 or No. 774

Comparative Properties of Corning Coil Form Glasses

	#790	#707	#774
Maximum Operating Temperature (°C)	800	425	500
Linear Expansion (0-300°C) per °C x 10^{-7}	8.5	31	32
Water Absorption—24 hrs.(%)	<.01	None	None
Volume Resistivity log R at 20° C	13.0	17.0	14.7
S.I.C.—20° C—1 MC	4.0	3.95	4.65
P.F.—20° C—1 MC (%)	0.18	0.06	0.42
L.F.—20° C—1 MC (%)	0.72	0.24	1.95

MULTIFORM COIL FORMS

This exclusive Corning Glass Works' method offers coil forms with all-round superior electrical characteristics . . . yet moderately priced in any quantity. Low coefficient of expansion. Most adaptable to complicated shapes or where multiple holes are required. Good thread contours. Can be metallized for applying mounting assemblies or terminal clips. Made from No. 790 glass only.

Pyrex Insulators

BRAND

"PYREX" is a registered trade-mark and indicates manufacture by Corning Glass Works

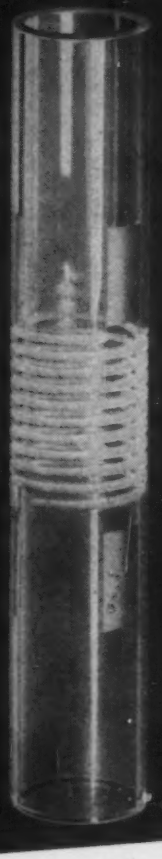
CORNING COIL FORMS EVERY NEED!

2

BLOWN COIL FORMS

In minimum quantities of 12,000 to 15,000 units for No. 774 glass, this Corning method provides coil forms at rock-bottom prices. Forms are unusually strong mechanically and are transparent for easy inspection of internal assemblies. Can be metallized for applying mounting assemblies or terminal clips. Can also be made from No. 707 glass in limited quantities by hand molding, for the duration.

3



PRECISION GROUND COIL FORMS

This method, while slightly more expensive, produces most accurate thread contours. Adaptable to any quantity. Has advantage of transparency. Mountings or terminal clips can be applied by metallizing. Made from either No. 707 or No. 774 glasses.

MAIL COUPON TODAY

Electronics Sales Department E-12-2
Bulb and Tubing Division
Corning Glass Works, Corning, N. Y.

Please send me the full story on Corning's 3 Coil form methods.

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Company .....

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with greater sensitivity and range than ever before accomplished

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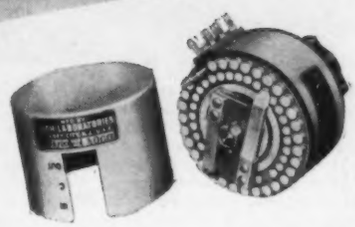
TECH LAB MICROHMMETER . . . *gives*

direct and instantaneous readings of resistance values

down to 5 microhms and up to 1,000,000 megohms. Accuracy in all measurements to better than 2%. Output is sufficient to drive recorder. Entirely AC operated. Reasonably prompt deliveries. For complete data regarding other applications, write for bulletin No. 432.



Quality manufacturers of attenuators and other electrical resistance instruments. For complete data . . . Write for bulletin No. 431.

TECH LABORATORIES

7 LINCOLN STREET · JERSEY CITY, N. J.

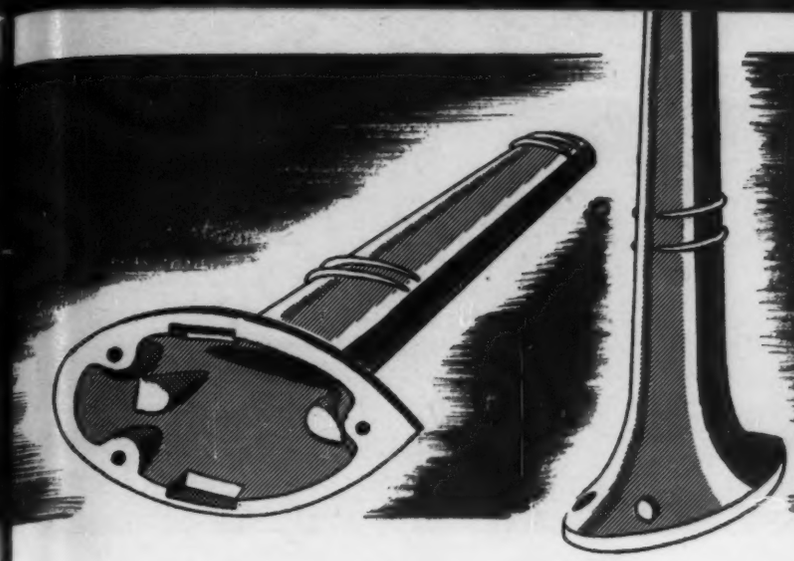
BLILEY CRYSTALS
RIDE WITH THE SCR-299
Built by hallicrafters

ONE of the outstanding achievements in wartime radio transmitter design is the SCR-299. Serving equally well as a mobile or stationary radio station, this now famous equipment is doing a real job on our battle fronts.

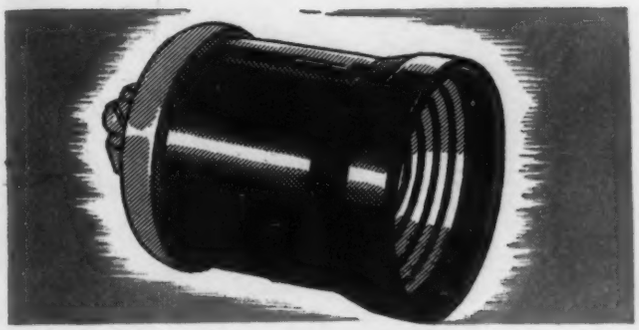
This war is run by radio. The vital importance of maintaining reliable communications necessitates the selection of quartz crystal units that are accurate and dependable. Bliley Crystals are engineered for service . . . they are used in all branches of military communications and are, of course, supplied for the SCR-299.

BACK THE ATTACK WITH WAR BONDS

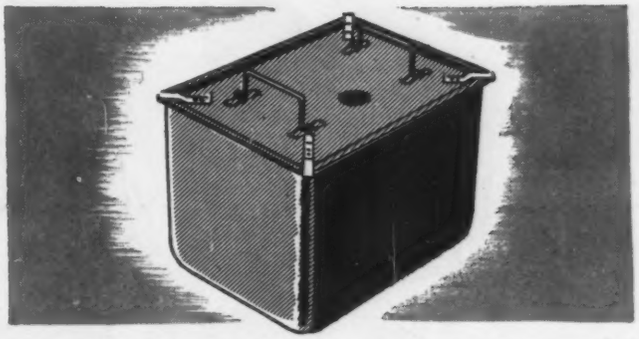
BLILEY ELECTRIC CO., ERIE, PA.



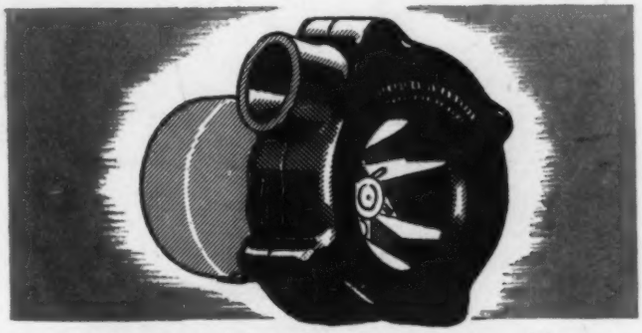
AN INTERESTING FEATURE of the huge Curtiss Commando troop transport plane is its use of an extremely lightweight, yet tough and durable antenna and pitot tube, molded at low pressure using a BAKELITE laminating resin. To provide strength needed to withstand air pressures encountered in flight, the mast is molded in one piece, using a special "creped" cloth. Unlike conventional laminating cloth, this material, after it is impregnated with BAKELITE phenolic resin, is "creped" so that it can stretch in all directions in the molding process. Since the laminations remain intact, the finished mast has unusually high mechanical strength.



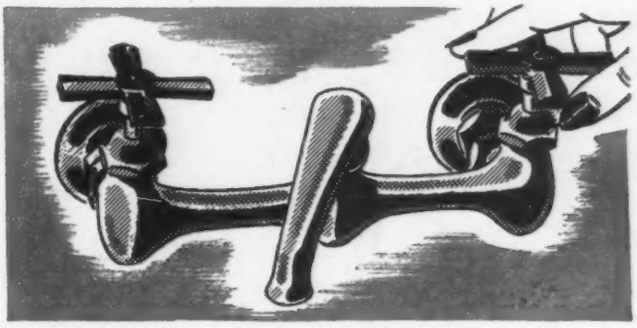
Now, lighting fixture sockets aboard America's Victory Ships are molded of BAKELITE phenolic plastics. They are lighter, more compact, and more durable than sockets previously used. The manufacturer found that less breakage and faster assembly made possible a production jump of 10 to 15 per cent . . . pushed costs down 10 per cent. The new socket has been approved for use aboard all ships of our Merchant Marine, where it will withstand vibration and extremes in temperature change.



The lining of the food containers used in Medical Corps hospital food carts must stand up against constant scraping with ladle or spoon when serving, and sudden temperature changes on sterilizing. That's a tough assignment for any coating. Yet a BAKELITE resin baking finish does the job—and does it well. Known best before the war for its use in insulating and bonding armature and coil windings, these glasslike coatings have passed many rigid requirements in meeting today's wartime needs in replacing plated linings for cans, drums, and tanks.



A tiny blower measuring only four inches in diameter, weighing only four ounces, cools the radio and other electronic equipment on America's fighting aircraft. Using a BAKELITE general-purpose phenolic molding material, the manufacturer has been able to mold the lightweight blower housing to close tolerances, yet secure good heat resistance and mechanical strength.



Army, Navy. Federal housing developments, and Navy and Maritime ships are using plumbing accessories molded of BAKELITE cellulose acetate. Five hundred thousand faucet handles have already been produced—and are proving highly successful because of their low heat transmission, good heat resistance, fine appearance, and resistance to corrosion. Other developments include a shiny white elbow, for toilet flush tanks that will not shrink or distort in service.

types of laminated plastics made with BAKELITE laminating varnishes, and illustrates many applications. Outlines fabricating techniques, and gives ASTM data.

BOOKLET 7-V "BAKELITE HEAT-HARDENABLE VARNISH, ENAMEL, LACQUER, CEMENT" — A 40-page illustrated booklet. Describes resin-baking coatings and bonding materials—their properties, uses, and advantages.

BOOKLET 7-F "BAKELITE C-9 RESINS" —A 12-page illustrated booklet for the paint and varnish technologist. Shows how these new resins accelerate bodying time and improve performance of many surface coatings.

BOOKLET 7-J "BAKELITE COATING PRODUCTS" — A 4-page folder for the paint and varnish technologist, describing the new water emulsions based on C-9 resins.

BOOKLET 7-Q "BAKELITE SEALING SOLUTIONS FOR POROUS CASTINGS" —A 4-page folder that tells how to reclaim porous and spongy castings by impregnating with resin-baking solutions.

BAKELITE

TRADE MARKS

The word "Bakelite" and the [B] symbol are registered trade-marks identifying products of Bakelite Corporation

Plastics Headquarters

THESE 7 SOLUTIONS MAY SOLVE 700 OTHER PROBLEMS...

...perhaps your own

"BAKELITE" PLASTICS—Problem Solvers for Industry

When one manufacturer solves a wartime production problem by using the right BAKELITE plastic, the result may be helpful to many other manufacturers. In this spirit, we pass along here the solutions to seven typical problems, any one of which may provide the answer to yours. The plastic materials discussed are, of course, available only for highly essential uses.

Do you have a tough coatings problem? In recent tests, steel panels coated with a BAKELITE resin primer showed no blistering, pimpling, or rusting after 8,000 hours of continuous water immersion, while other primers failed at 300 hours.

Does the molding of pieces thicker than ⅜ inches, using thermosetting materials, interest you? Heatronic molding, a recent development of the Bakelite Laboratories, makes this possible, speeds curing time 10 to 50 per cent, drops molding pressure 30 to 40 per cent.

These examples are typical of the scores of developments you will be posted on if you keep in touch with Bakelite Plastics Headquarters. Our Engineering Staff and Development Laboratories have amassed a wealth of data that can help you now with your essential production problems, or with your plans for the days to come.

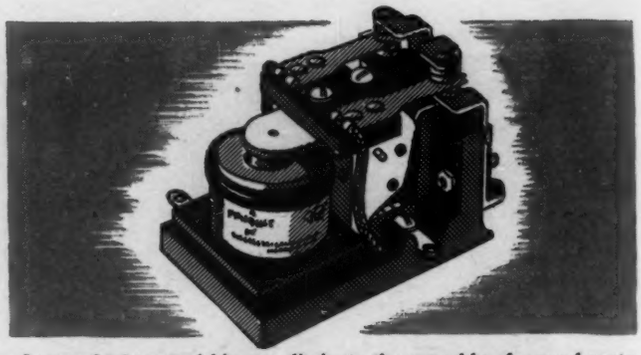
Write for specific technical literature. Please address Department 7.

BAKELITE CORPORATION

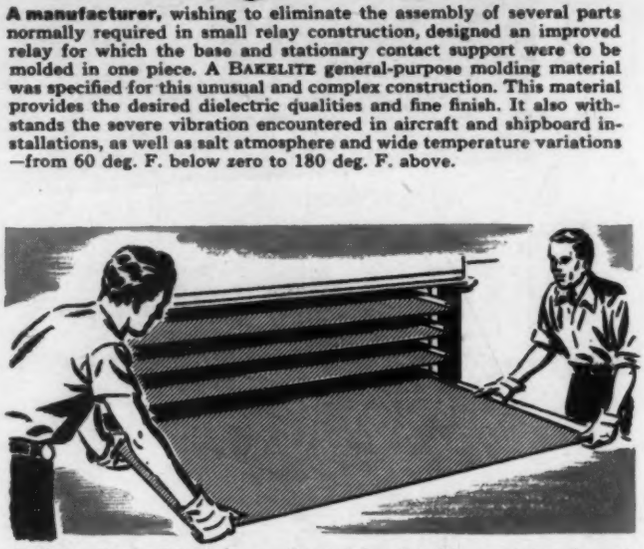
Unit of Union Carbide and Carbon Corporation

UCC

30 EAST 42ND STREET, NEW YORK 17, N.Y.



A manufacturer, wishing to eliminate the assembly of several parts normally required in small relay construction, designed an improved relay for which the base and stationary contact support were to be molded in one piece. A BAKELITE general-purpose molding material was specified for this unusual and complex construction. This material provides the desired dielectric qualities and fine finish. It also withstands the severe vibration encountered in aircraft and shipboard installations, as well as salt atmosphere and wide temperature variations —from 60 deg. F. below zero to 180 deg. F. above.



Today, plywood can be made sturdy, durable, waterproof, and weather-resistant—with BAKELITE phenolic resin glue. Wartime applications, such as the plywood airplane and glider, Army truck bodies, and Navy PT boat sections have demonstrated these properties. Recently, carloads of BAKELITE phenol-bonded plywood were sent abroad to make pontoon bridges—stub-nosed boats that will float on rivers for months at a time, withstanding weathering and hard wear.

Useful Literature on Plastics

BOOKLET 7-A "BAKELITE HORIZONS"—This pamphlet provides a brief introduction to BAKELITE plastics. Describes the origin of plastics . . . their forms, fabricating techniques, and applications.

BOOKLET 7-P "A SIMPLIFIED GUIDE TO BAKELITE PLASTICS"—A 16-page, illustrated booklet that describes, in digest form, the various types of BAKELITE plastics and synthetic resin products.

BOOKLET 7-M BAKELITE MOLDING PLASTICS"—A 32-page illustrated reference booklet. Gives technical descriptions of the various BAKELITE thermosetting and thermoplastic molding materials.

"MOLDING TECHNIC FOR BAKELITE AND VINYLITE PLASTICS" (Price $3.50)—A 224-page manual on the art of molding plastics. Contains latest technical data the designer, engineer, molder, and user should know about designing and fabricating hot-set and cold-set molding materials.

BOOKLET 7-L "BAKELITE LAMINATING PLASTICS"—A 24-page illustrated booklet. Describes, in detail, various

Hallicrafters has the honor of being the first exclusive manufacturer to receive the Army-Navy Production Award for the third time! This third award adds a second White Star to Hallicrafters' flag—and stands as a symbol of their great contribution to the cause of freedom.

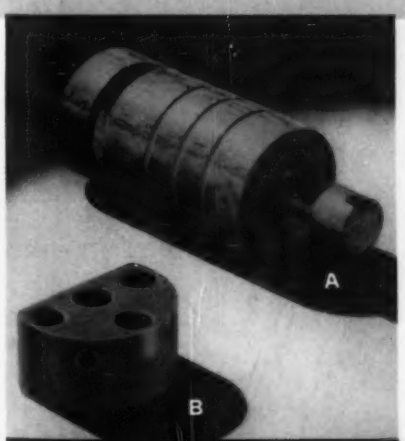
BUY MORE BONDS!

hallicrafters

THE WORLD'S LARGEST EXCLUSIVE MANUFACTURER OF SHORT WAVE RADIO COMMUNICATIONS EQUIPMENT

Official U. S. Navy Photograph

Scratch One Zero!



A—Airbrake piston—drilled, turned and grooved on the lathe, milled.
B—Insulator—bandsawed, turned, drilled, and counterbored.

WHEREVER Navy buzzard-busters swing into action, you'll probably find Synthane.

The reason is plain. The self-same qualities that suggested Synthane for peacetime products fit it for the implements of war. A few of these advantages worth pasting in your hat for future reference are light weight (half the weight of aluminum), excellent dielectric characteristics, resistance to corrosion, structural strength, and ease of machining. There are many more.

The time will come when ack-ack need no longer clear trouble-charged skies. Then industrial plastics, such as Synthane, will return and find many new jobs waiting. As you look forward to that day, read the data on the back of this sheet or write to us for present help on future work.

SYNTHANE CORPORATION, OAKS, PENNSYLVANIA

Plan your present and future products with Synthane Technical Plastics

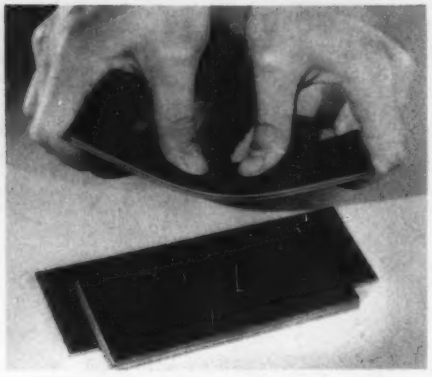
SHEETS • RODS • TUBES • FABRICATED PARTS **SYNTHANE** MOLDED-LAMINATED • MOLDED-MACERATED

SYNTHANE "Sandwich" Materials

One of the advantages of Synthane is the ease with which it can be bonded to other materials to produce a substance with the combined advantages of the partnership. Bonding takes place under heat and high pressure, during the polymerization of the Synthane; it is not a mere joining of two surfaces with an adhesive. The resulting combination, therefore, shows little or no tendency to delaminate.

Synthane combinations are familiarly known as Synthane "sandwich" materials, an appropriate name, for many different kinds of combinations are possible.

Probably the most widely used combination brings Synthane and rubber together.

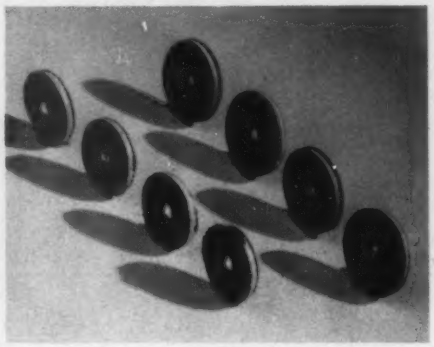


Synthane-Rubber

Synthane-rubber combinations are advantageous where the strength of Synthane is desirable to back up rubber.

An interesting application concerns a washer used in electrolytic and oil type condensers. The washer is placed on the end of tin can electrolytic condensers with the Synthane face exposed to the chemicals to prevent deterioration. The can is crimped into the rubber to make a tight seal.

A similar washer is used on "bath-tub" condensers. Tough Synthane provides a firm seat for a nut which compresses the rubber to form a tight joint.

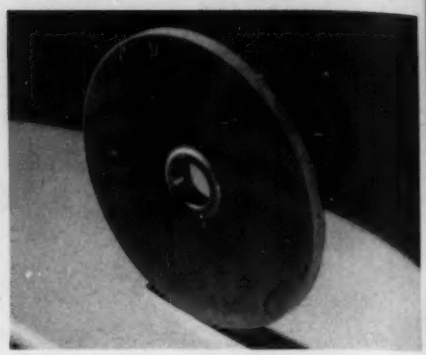


Combinations of rubber and Synthane have been furnished with rubber on one side, Synthane on the other; rubber on both sides with Synthane between; Synthane on both sides and rubber between; and alternate laminations of rubber and Synthane built up to any desired thickness.

There are many more possible uses for Synthane-rubber sandwich materials, which we cannot describe because of military censorship. There are also many important uses for a combination of Synthane and Neoprene.

Synthane-Synthane

Occasionally two grades of Synthane are combined. For instance, in certain radio tube sockets, layers of fabric and paper base Synthane are combined. The paper base has usually better electrical properties while the fabric base furnishes added strength where the stress is greatest.



Bobbin heads in the textile industry are often made of paper and fabric bases combined. The fabric base endures rough handling, whereas the paper base on the inside of the head provides a smooth wearing surface.

Synthane-Asbestos

Synthane is wound about asbestos (or fibre) tubes and cured in the manufacture of tubing for large fuse cases. Synthane adds strength and rigidity to the fire resistance of the asbestos or fibre.

Synthane-Other Materials

Synthane can be united with a variety of materials to produce a variety of practical combinations. We have made or experimented with other combinations. If you have any combination in mind which we have not explored, we will be glad to investigate its possibilities for you.

PLAN YOUR PRESENT AND FUTURE PRODUCTS WITH SYNTHANE TECHNICAL PLASTICS

SYNTHANE

SHEETS-RODS-TUBES-FABRICATED PARTS-MOLDED-LAMINATED-MOLDED-MACERATED

SYNTHANE CORPORATION, OAKS, PENNA.

REPRESENTATIVES IN ALL PRINCIPAL CITIES

On Every Fighting Front!

Crystals are doing a vital war job . . . approved precision Crystals are in use on every fighting front doing an unseen, but all important function with the communications equipment of our armed forces.

Crystal
PRODUCTS COMPANY
1519 McGEE STREET · KANSAS CITY, MISSOURI

Producers of Approved Precision Crystals for Radio Frequency Control

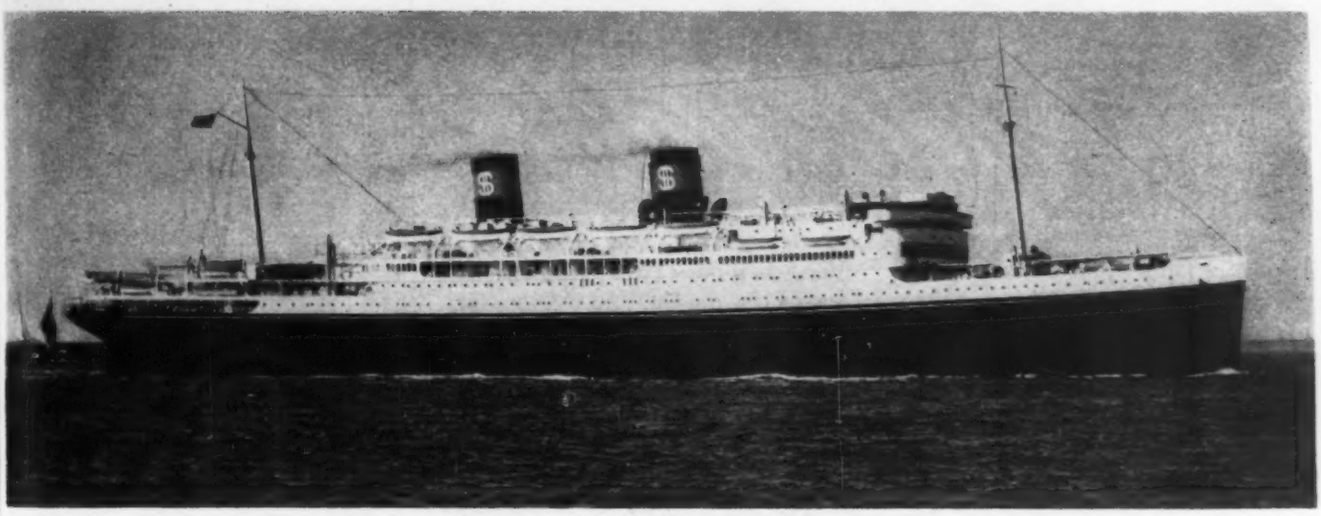
Before the "Presidents" Put on War Paint...

Before the war, shippers and travelers knew two years in advance the exact day a President liner would arrive or depart from any of the major ports of the world! Today the movement of these gray-clad transports is strictly hush-hush... but they continue to ply the seas with the same remarkable dependability.

For many years Heintz and Kaufman transmitters and Gammatron tubes have made these liners one of the most cohesive networks afloat.

Today Heintz and Kaufman Ltd. is concentrating exclusively on the design and manufacture of electron tubes.

The experience of our engineers in ship-to-shore and ship-to-ship communication is embodied in Gammatron tubes. The efficiency and reliability of these tubes at high



and very high frequencies, which makes them first choice for marine transmitters, is equally advantageous in all types of radio transmission.

HEINTZ AND KAUFMAN LTD.

SOUTH SAN FRANCISCO • CALIFORNIA, U. S. A.

Gammatron Tubes

ARMY E NAVY

LEADERS IN ELECTRONICS • YESTERDAY • TODAY • TOMORROW

Pat. Pending

- ★ *Oil Impregnated - Oil Filled*
- ★ *Oil Sealed*
- ★ *Ceramic or Bakelite Tubes*
- ★ *Bakelite Cement Ends (Oil Proof)*
- ★ *Suitable for Operation 75° to 100° C*
- ★ *Ideal for Extreme High Altitude Duty*
- ★ *No Danger of "Flash Over"*
- ★ *No Metal for "Body Capacity"*
- ★ *No Internal Corrosion*

DUE TO ITS CONSTRUCTION

The Egyptian Pyramids stand majestically, through the ages, as mute witnesses to the skill and rugged craftsmanship of the thousands of slaves who toiled to erect them . . . TODAY . . . not slaves . . . but creative engineering skill and willing hands achieved the same result with the new DUMONT TYPE PC2 Oil Paper Capacitor . . . an oil impregnated oil sealed capacitor that gives assured "LONGER LIFE" for continuous operation . . . Its special features and construction are exclusive with Dumont.

DUMONT

ELECTRIC CO.

MFR'S OF
CAPACITORS FOR EVERY REQUIREMENT
34 HUBERT STREET NEW YORK, N. Y.

Most far-sighted airport plan yet developed for the Southwest is this Oklahoma City project.

What is missing in this picture?

Missing to the eye . . . but a vital part of this super airport, and every other modern airport and airline . . . is the radio traffic control equipment without which the landing and take-off of planes would become a hopeless jumble. Missing, too, are the radio navigational aids—ranges, markers and communication transmitters and receivers so necessary to the guidance of flight.

In peacetime, RADIO RECEPTOR, in conjunction with the Civil Aeronautics Authority, played an important role in equipping airlines, and airports such as the La Guardia and Washington National Airports. In wartime, we have supplied the Signal Corps with equipment which is now in use in more than 180 airfields in the United States . . . and we don't know how many in foreign lands.

Send for a copy of our non-technical booklet, "Highways of the Air"—you'll find it interesting.

"Laymen are inclined to think of an air route as simply a corridor of air through which planes commonly fly. But it is more than that. It is, first, a system of air fields, each of which, wherever it may be,* must have *runways and* radio *and other communications. In laying out an air route and the fields along it, a complete system of communications, from point-to-point and from* ground-to-air, *along with* radio beacons *and other navigational aids, must be set up."

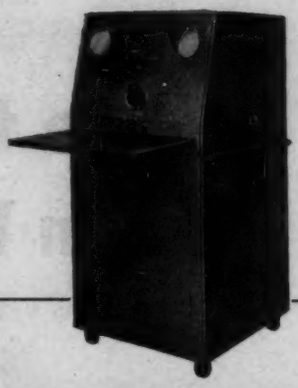
—MAJOR GENERAL HAROLD LEE GEORGE
Commanding General, Air Transport Command

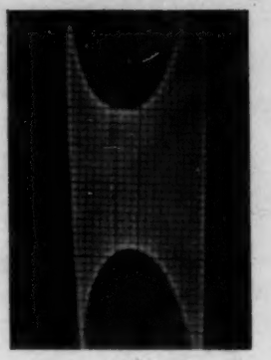
Awarded for Meritorious Service on the Production Front

Radio Receptor Co.
INCORPORATED
251 WEST 19th STREET NEW YORK 11, N. Y.

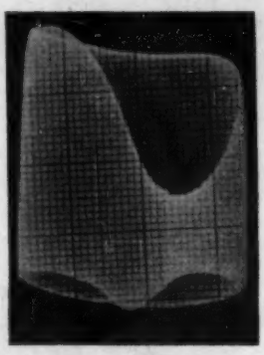
★ SINCE 1922 IN RADIO AND ELECTRONICS ★

Cathode-Ray Technique Now Goes to the Aid of the Metallurgist . . .





Typical DuMont cyclogram as read by the operator. This reading is for the depth of case-hardening. Each division of grating represents .01". Waist thickness equals 22 tenths, or closely corresponding to micrograph examination of same piece.



Another DuMont cyclogram, this time indicating high internal stresses. The Cyclograph may be used to distinguish between two pieces of steel having the same hardness, one of which has low internal stresses and the other higher internal stresses and therefore more brittle.

DuMONT *Cyclograph*

Still another typical DuMont case history . . .

Wartime metallurgists are scarce. Yet metallurgical requirements are highly critical. In some processes incoming materials must be 100% checked for exact metallurgical properties. Finished production is individually checked since faulty pieces might get by percentage or spot checks. No chances can be taken with the lives of our fighting men. What to do?

The problem was given to DuMont cathode-ray specialists. In due course the DuMont Cyclograph evolved. Here is a truly revolutionary means of metallurgical checking and automatic sorting. After undergoing exhaustive tests at the hands of metallurgists, production men and ordnance experts, it is now offered not only as an instrument but as a continuing engineering service, on a lease basis. Thus another milestone in production uniformity, efficiency, economy, in war and in peace.

Cathode-ray technique may be applicable to your industrial or engineering problems. Write on business stationery for the new DuMont Manual. And submit that problem for engineering suggestions or recommendations.

DUMONT *Precision Electronics & Television*

ALLEN B. DUMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: WESPEXLIN, NEW YORK

G-M

● The G-M Type 29 Relay is designed mechanically and magnetically to give unusual efficiency and dependability in operation. Its small size and light weight combined with rugged construction, characteristic of all G-M relays, make it ideal for a multitude of communications uses. The Type 29 is positive in action and requires an exceptionally low power input.

Numerous circuit combinations are available to meet practically any requirements. The high efficiency of the magnetic circuit insures high contact pressure. Phosphor bronze armature bearings, turning in accurately reamed holes in a brass bracket, insure free operation and long life. The contact springs and anti-vibration springs are of nickel silver. Mycalex insulators are available if specified. All steel parts are heavily cadmium plated and the coil is carefully impregnated so that the entire unit will withstand 200 hour 20% salt spray tests. The illustration above is actual size.

A free standardized sample of the Type 29 relay shown above, specification No. 12899* is available for examination and test to manufacturers who are prospective relay users. Orders for free samples must be accompanied by a priority of AA-4 or better.

*No. 12899 samples have 12 volt D-C coils, two double throw contacts and one single throw normally closed contact.

VISITRON PHOTOTUBES

are available in numerous sizes. Made by G-M, pioneer in development and manufacture of quality phototubes.

G-M LABORATORIES INC.

4313 NORTH KNOX AVENUE, CHICAGO 41, ILLINOIS

Buy WAR BONDS & STAMPS

"VIBRATION TESTED"

Callite Tungsten Filaments can take the tough going of our hard-hitting invaders. In Tung-Sol "vibration-tested" Radio Tubes, noted for their "praiseworthy performance", Callite Tungsten Filaments function with the absolute fidelity required to meet not only Tung-Sol's rigid tests, but to prove their stamina in action.

Check all Four

Makers of sturdy, dependable radio and electronic devices rely on Callite for ✔ Precision Products, controlled throughout production by long-experienced, technically-trained men; ✔ for Expert Metallurgical and Engineering advice and cooperation; ✔ for consistent deliveries —the ability to meet emergencies; for ✔ Top Quality at a fair price.

Check all four factors important to your production when seeking a source of supply—then call Callite Tungsten Corporation, 544-Thirty-Ninth St., Union City, N. J. Also Chicago and Cleveland.

CALLITE **SPECIALISTS in the manufacture of welds, lead-in wires, filaments grids, formed parts, electrical contacts, and other raw materials for electronic applications.**

Centradite

A New CENTRALAB development in Ceramic material

Centradite has these outstanding characteristics:

LOW THERMAL EXPANSION • HIGH RESISTANCE TO HEAT SHOCK • LOW POROSITY • LOW LOSS FACTOR

These important characteristics are combined with excellent dielectric properties making it suitable for use in radio frequency circuits. (See Chart).

Centradite is particularly recommended for coil forms where thermal expansion must be low to prevent undue change in inductance.

Centradite is ideal where the application requires that the material withstand a rapid increase or decrease in operating temperature within a short period of time.

Centradite can be supplied in various shapes by extrusion or pressing.

Centradite, due to its resistance to heat shock, lends itself to a new process of soldering metal to ceramic, whereby the ceramic surface is metalized to permit soldering.

We invite inquiries regarding the further uses which may fit your applications.

Description of Material	Body No. 400
Thermal coefficient of expansion per degree Centigrade	20-100 C° 1.9×10^{-6} 20-600 C° 3.1×10^{-6}
Modulus of rupture in lbs. per sq. in.	13,000 lbs.
Dielectric constant	5.4
Dielectric loss factor	3.00 or less
Grade per American Stand. C75.1-1943	Class "L3" or better
Porosity or moisture absorption	Zero to .007%
Color of material	White

Centralab

Division of GLOBE-UNION INC., Milwaukee

Centralab
Ceramic
Trimmers
provide the ideal trimmer capacitor where controlled temperature coefficient and mechanical stability is required.
Temperature coefficients available:
Types 820, 822, 823, 824
Maximum negative .0005 mmf/mmf/oC
Types 822, 823, 824 . . . . . Zero
Type 823 . . . Positive .0002 mmf/mmf/oC
Write for Bulletin 695
Centralab
Division of GLOBE-UNION INC., Milwaukee

5 WBCA
Schenectady, N. Y.
110 MILES
FM
2 WFMN
Alpine, N. J.
70 MILES
FM
25 MILES
FM
1 WGYN
New York City
40 MILES
WDRC—
Hartford

6 WMTW
Mt. Washington, N. H.

4 WGTR
Paxton, Mass.

120 MILES

40 MILES

WDRC—FM
Hartford, Conn.

Perfect copies of her voice ...over an FM wireless network

CRYSTAL-CLEAR! Programs picked up *out of the air* and rebroadcast—again and again! With no appreciable loss of fidelity! With amazing freedom from static! Perfectly repeated "copies" of the originating broadcast!

This is a practical reality. It is the definite promise of the modern FM chain-broadcasting technique for the sectional network of tomorrow. Already this FM technique is proving itself in time-tested daily use over New England's FM American network—with negligible distortion—with FM's amazing freedom from station interference — and with full coverage of *the whole audio range of the human ear.* . . . All this with no increase in the exceptionally low noise level of FM.

On regular FM wave-lengths, programs originating in New York's WGYN are relayed to Alpine, N. J., Hartford, Conn., the Paxton station near Worcester, Mass.; then picked up and again rebroadcast by stations at both Schenectady, N. Y., and Mt. Washington, N. H. (With the proper equipment, *any station* in such a network can originate a network program.)

General Electric furnished a substantial portion of the FM equipment for this chain. In fact, G.E. has furnished more than a third of all FM transmitters in America; and a large percentage of the half-million FM receivers.

That FM regional and national network broadcasting will grow rapidly is General Electric's confident prediction. For chain rebroadcasting seems the practical answer to regional FM broadcasts, and General Electric's exclusive S-T relay equipment points the way toward national FM networks. This efficient studio-to-transmitter link permits studio location for maximum convenience and transmitter location for maximum coverage . . . *without wires!*

A PLAN
that will secure your place in radio broadcasting post-war

General Electric offers you "The G-E Equipment Reservation Plan". . . a plan designed to enable you to complete *your* post-war plans *now.* It will enable you to establish a post-war priority on a broadcast transmitter and associated equipment. It will enable us to plan definitely for large-scale post-war production, thereby giving you the fastest possible post-war delivery and the savings of planned production. Investigate this plan today and assure your place in radio broadcasting post-war. *Electronics Department, General Electric, Schenectady, New York.*

Tune in "THE WORLD TODAY" *and hear the news direct from the men who see it happen, every evening except Sunday at 6:45 E.W.T. over CBS. On Sunday listen to the G-E* "All Girl Orchestra" *at 10 P.M. E.W.T. over NBC.*

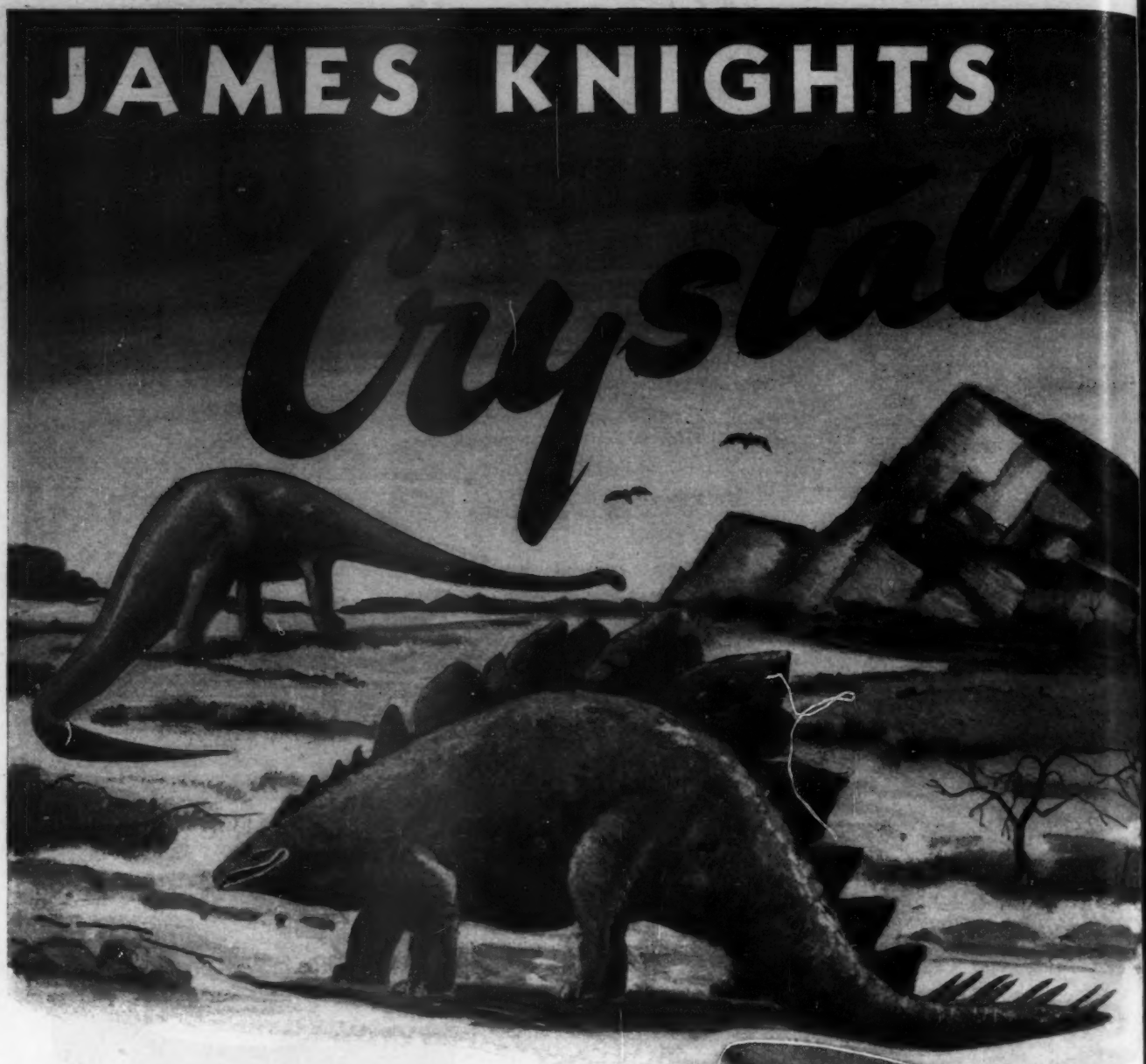
BACK THE ATTACK — BUY WAR BONDS!

GENERAL ELECTRIC 160-811 FM · TELEVISION · AM

See G.E. for all three!

JAMES KNIGHTS

Crystals



Quality crystals once formed, may last unchanged for millions of years — to the day the important "first cuts" are taken to make them useful to man. It is in these first steps of precision fabrication, and in those that follow, that the skill of James Knights craftsmen plays its part. Every James Knights Crystal is designed and cut to exacting specifications by America's most modern methods. No wonder, with the finest of raw materials and advanced manufacturing techniques, James Knights can produce, in volume, dependable crystals of every type, cut and frequency. Why not let James Knights specialists help with your requirements?

BUY WAR BONDS FOR VICTORY!

The JAMES KNIGHTS Co.

SANDWICH, ILLINOIS Phone 65

PRECISION CUTTERS OF QUARTZ FOR COMMUNICATIONS AND OPTICAL USES

EVERYONE IS TALKING ABOUT THE NEW *Electro-Voice* ACHIEVEMENT

NICKNAMED THE "LIP-MIKE"

Officially known as the T-45, the

Electro-Voice
DIFFERENTIAL MICROPHONE
is also affectionately termed the "Schickelgruber"

Developed by Electro-Voice engineers in close collaboration with the Fort Monmouth Signal Laboratory, the T-45 marks the beginning of a new era in which voice transmission is unaffected by ambient noise or reverberation. It accomplishes such complete suppression of background that speech from a battlefield or from the deafening interior of a moving tank is accompanied by hardly a trace of noise.

The "Lip-Mike" is a Differential Microphone designed to fit under a gas mask without breaking the seal — small enough to allow an Armored Force respirator to slide over it — and has been standardized for all Army Ground Forces.

- *Frequency response substantially flat from 200-4000 cps.*
- *Low harmonic distortion*
- *Cancellation of ambient noise, but normal response to user's voice*
- *Self-supporting, to free both hands of the operator*
- *Uniform response in all positions*
- *Usable when gas mask, dust respirator or oxygen mask is required*
- *Unaffected by temperature cycles from −40° F. to +185° F.*
- *Ability to withstand complete immersion in water*
- *Physical strength to withstand 10,000 drops*
- *Weight, including harness, cord and plug, less than 2 ounces.*

WHEN PEACE COMES, THERE WILL BE DIFFERENTIAL MICROPHONES OF MANY TYPES FOR CIVILIAN USES IN WHICH THESE ADVANTAGES WILL BE OF REVOLUTIONARY IMPORTANCE. THUS, ANOTHER WARTIME DEVELOPMENT WILL FIND ITS GREATEST VALUE IN THE COMING OF PEACE.

Electro-Voice MICROPHONES

ELECTRO-VOICE MANUFACTURING CO., INC. · 1239 SOUTH BEND AVENUE · SOUTH BEND, INDIANA
Export Division: 13 East 40th Street, New York 16, N.Y. — U.S.A. Cables: ARLAB

This generator armature has been "Harvelized" by Hanson-Van Winkle-Munning Company. They use Harvel varnish because – (1) bakes quicker – (2) bakes harder – (3) does not become brittle – (4) lasts longer.

THE SECRET OF BETTER INSULATION in a NUTSHELL

FROM the shell structure of the familiar Cashew nut comes a natural phenol which is the basic component of Harvel Insulating Varnishes. The discovery of this unique insulating ingredient which has been utilized by Irvington in the manufacture of a superior insulating varnish is the result of exhaustive research and an experience of over thirty-six years in making all types of insulating varnishes.

Harvel varnishes have many excellent insulating properties which add years to the life of motors, generators, transformers and other electrical equipment. They possess the highest safety factors even when operating under excessive heat, heavy over-loads and in atmospheres where acid or alkali fumes and abrasive materials are present. For example:

Motor failures in a large chemical plant occurred every three months until Harvel varnish was used. Now, three years of uninterrupted service on these same motors is not unusual. This is typical of Harvel performance under extreme conditions.

Harvel reduces the time necessary to produce a unit of electrical equipment by cutting the average baking time in half on applications involving multiple coats. It polymerizes to a solid infusible state and will not soften or "throw-out" at high peripheral speeds.

Harvel varnishes have excellent dip-tank stability—exceptional penetrating power—and contain no objectionable solvents.

Because the unusual features of Harvel varnishes are not all disclosed by ordinary laboratory methods of testing, why not get these facts first-hand? We will gladly send you a generous sample for testing. See for yourself how Harvel varnishes are superior for use with any type of insulation – for application on equipment wound with Formex and Formvar coated wire, Fiberglas, cotton, asbestos, and paper or enameled wire of all classes.

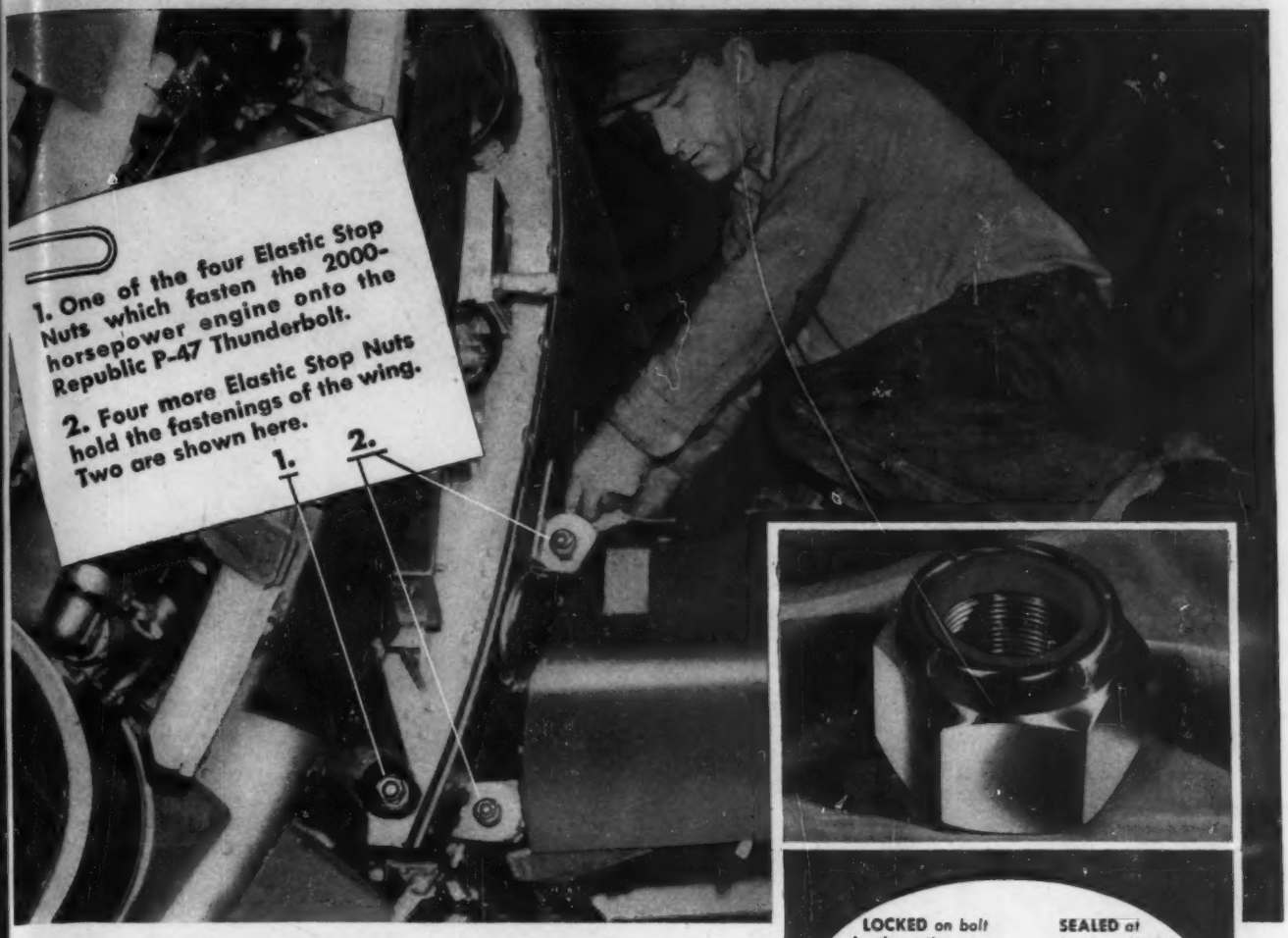
For catalog, samples, or for technical assistance on unusual problems, write Dept 106.

Irvington

VARNISH & INSULATOR CO.

IRVINGTON, NEW JERSEY, U. S. A.

PLANTS AT IRVINGTON, N. J. & HAMILTON, ONT., CAN. • *Representatives in 20 Principal Cities*


1. One of the four Elastic Stop Nuts which fasten the 2000-horsepower engine onto the Republic P-47 Thunderbolt.
2. Four more Elastic Stop Nuts hold the fastenings of the wing. Two are shown here.
1.
2.

LOCKED on bolt by the action of the gripping red collar
SEALED at top to protect working threads from corrosion
PLASTIC collar cushions vibration—nut can't shiver loose
FITS any standard bolt. Made in all sizes and types

You've gotta hang on when you say "Giddap" to 2,000 horses

When the pilot of a Republic P-47 pours on the soup, 2,000 surging, throbbing horsepower yank him into the high blue heavens.

When he climbs straight up he is literally hanging on his prop and engine.

And those tons of plane, man and armament hold onto that engine with just four Elastic Stop Nuts.

This is the kind of job that has given Elastic Stop Nuts the reputation of having revolutionized modern aircraft construction. It's the reason you find over 12,000 of them on the P-47 and as many as 50,000 on some types of bombers.

It's all because these nuts hold fast — without auxiliary locking devices. They're applied like ordinary nuts. They can be removed and replaced time and again without losing locking effectiveness. They stay put, and nothing, even violent vibration, shakes them loose.

It's done by the red elastic collar in the top. This collar clings tightly around the bolt threads. It absorbs and cushions vibration from every direction. The nut can't shiver loose — can't turn.

Postwar progress will present countless fastening problems which these nuts will solve. Perhaps you already are studying such problems. If so, let us know about them. Our engineers will be very glad to help work out a solution and show you how an Elastic Stop Nut will provide a safer, surer, trouble-free fastening.

ELASTIC STOP NUTS

Lock fast to make things last

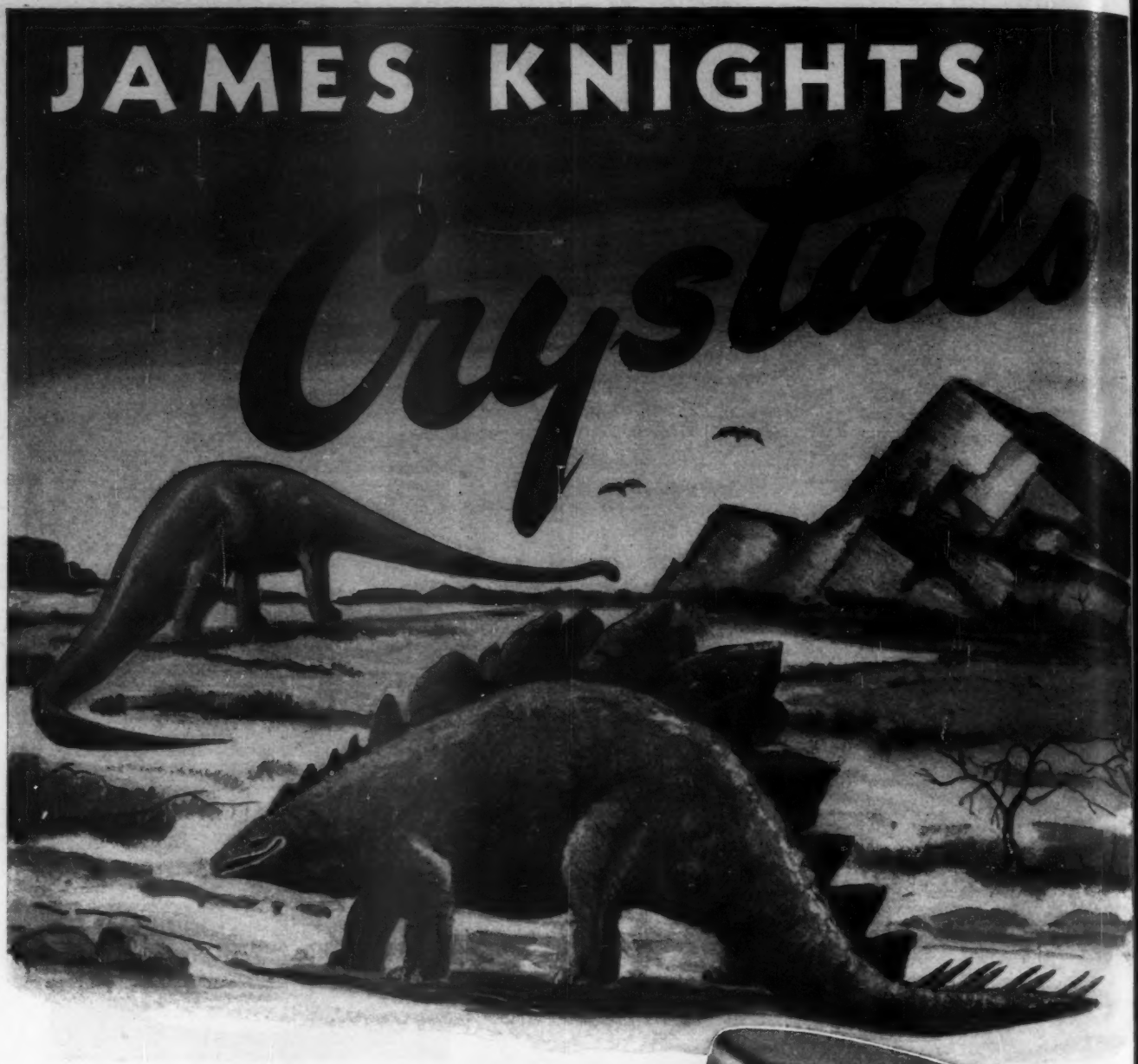
ESNA TRADE MARK

BACK THE ATTACK . . . BUY WAR BONDS

ELASTIC STOP NUT CORPORATION OF AMERICA

UNION, NEW JERSEY AND LINCOLN, NEBRASKA

JAMES KNIGHTS



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- *Unaffected by temperature cycles from −40° F. to +185° F.*
- *Ability to withstand complete immersion in water*
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Export Division: 13 East 40th Street, New York 16, N. Y. — U. S. A. Cables: ARLAB

FROM OUR MILLS TO THE MOON

Placed end to end, the cartridges made for this war from brass produced by our mills would reach clear to the moon and more than halfway back to the earth—a total of 374,885 miles.

Such volume production staggers the imagination—yet for every cartridge in every billion produced by Western-operated ammunition plants, our brass mills are rigidly holding to unbelievably close tolerances.

In addition, hundreds of thousands of tons of "tailor-made" brass are being produced for many other types of war equipment by our mills at East Alton, Ill., and New Haven, Conn., thereby contributing to the day when Victory will again make it possible for us to serve you.

BRASS PRODUCTS
WESTERN CARTRIDGE COMPANY
EAST ALTON, ILLINOIS, U. S. A.

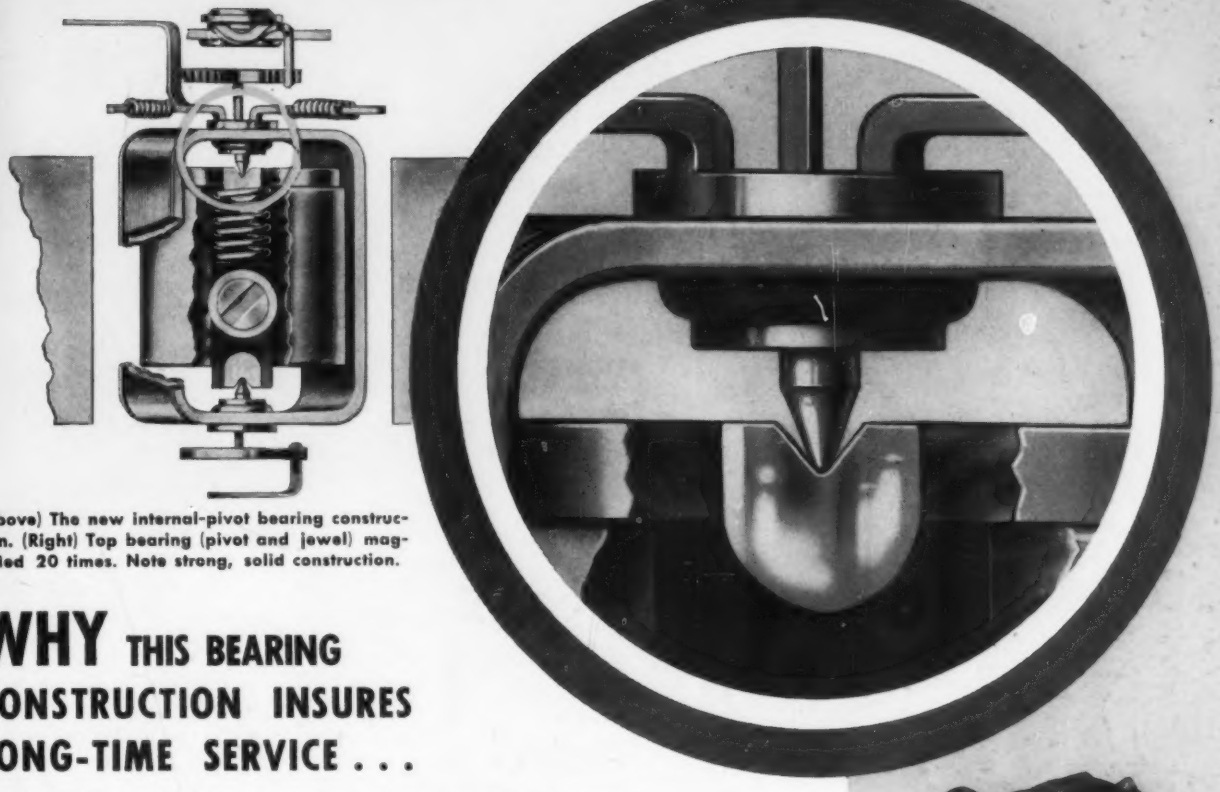
Western BRASS MILLS

Division of WESTERN CARTRIDGE COMPANY, *East Alton, Ill.*

New INTERNAL-PIVOT ELECTRIC INSTRUMENTS

2½-inch - - - 1 inch deep

For radio and other communications service; d-c voltmeters, ammeters, milliammeters, microammeters, and radio-frequency ammeters and milliammeters (a-c thermocouple type). Cases are brass or molded Textolite.



(Above) The new internal-pivot bearing construction. (Right) Top bearing (pivot and jewel) magnified 20 times. Note strong, solid construction.

WHY THIS BEARING CONSTRUCTION INSURES LONG-TIME SERVICE . . .

IN THESE new G-E instruments, the pivots are solidly mounted on the *inside* of the armature shell instead of being cemented to the outside of the armature winding. The result is a rigid construction that helps to maintain accurate alignment.

The steel pivots, highly polished, are of the aircraft type, larger than normal. This means less stress on the bearing surfaces and a construction that will stand rough treatment and shock.

The pivots rotate in low-friction, highly polished, glass vee jewels—one mounted rigidly in the top of the frame-and-core assembly, and the other mounted in a movable lower jewel sleeve located in the soft-iron core.

This combination—accurately formed, hard-glass jewels and large-radius steel pivots—provides a co-ordinated bearing that has proved, by field tests, to be excellent from the standpoint of long life and ability to withstand vibration.

Thin, Strong, Accurate Instruments

1. *Thinness* is obtained by solidly mounting the pivots on the inside of the armature shell. Most instruments are approximately one inch deep.
2. *Strength* is obtained by short, solidly mounted, large-radius pivots and the extra-strong over-all case.
3. *Sustained Accuracy* is insured by the featherweight moving element, combined with high torque and permanent alignment of all parts.

For ratings, prices, and dimensions, ask our nearest office for Bulletin GEA-4064, which covers instruments for use in radio and communications equipment; or Bulletin GEA-4117, which describes those suitable for naval aircraft. *General Electric Co., Schenectady, N. Y.*

D-c voltmeters, volt-ammeters and ammeters are specially designed to measure voltage and current in battery and battery-charging circuits on naval aircraft. They meet applicable Navy specifications.

SMALL PANEL INSTRUMENTS

GENERAL ELECTRIC

602-44-6200

LECTROFILM

TYPICAL CHARACTERISTICS

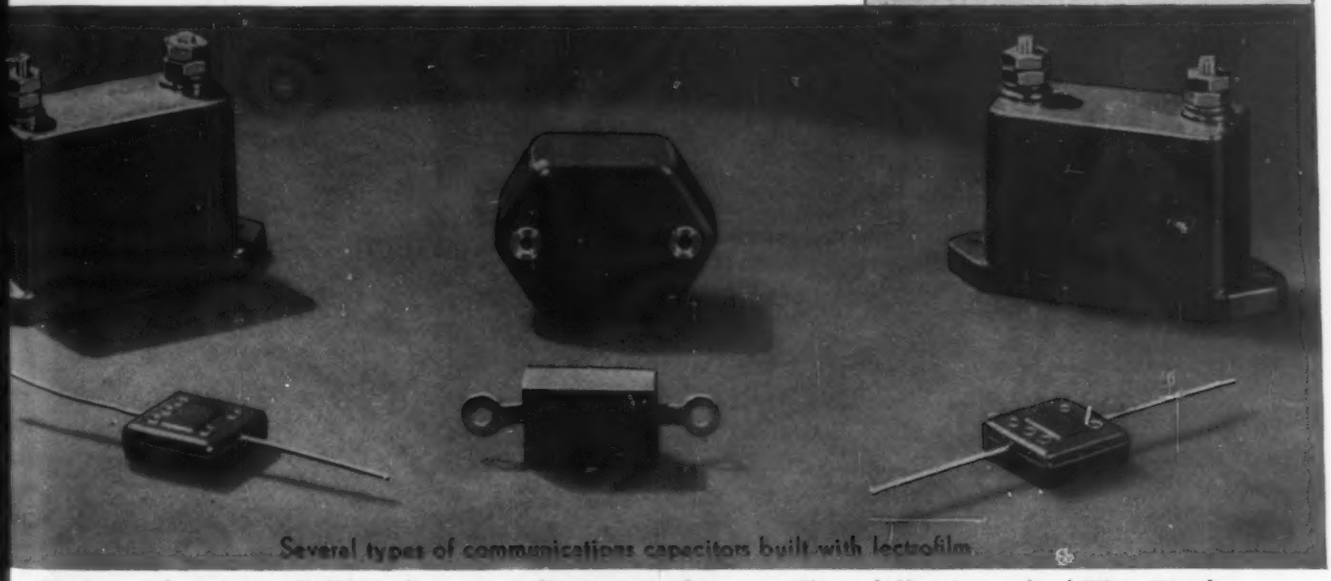
	Lectrofilm in Rolls, No. 2681	Lectrofilm in Sheets, No. 2682
D-c breakdown strength	1900 volts per mil (Two or more thicknesses)	2500 volts per mil
Dielectric constant	4.0 or more	5.5 or more
Tensile strength	Equal to Kraft capacitor paper	Equal to Kraft capacitor paper
Power factor at 1,000,000 cycles* Per cent at 25 C Per cent at 100 C	3.5 or less 1.75 or less	2 or less 1 or less
Capacitance temperature coefficient, per cent per degree C*	0.05 to 0.15	0.05 to 0.15
Maximum recommended operating temperature	100 C	125 C

**These characteristics, determined by actual test results on capacitors built with lectrofilm, will depend on the type of capacitor construction.*

For information on

- **sizes**
- **thicknesses**
- **weights**
- **additional characteristics**

...write for Bulletin GEP-217A. Address: Section 16-216, General Electric Company, Pittsfield, Mass.



Several types of communications capacitors built with lectrofilm

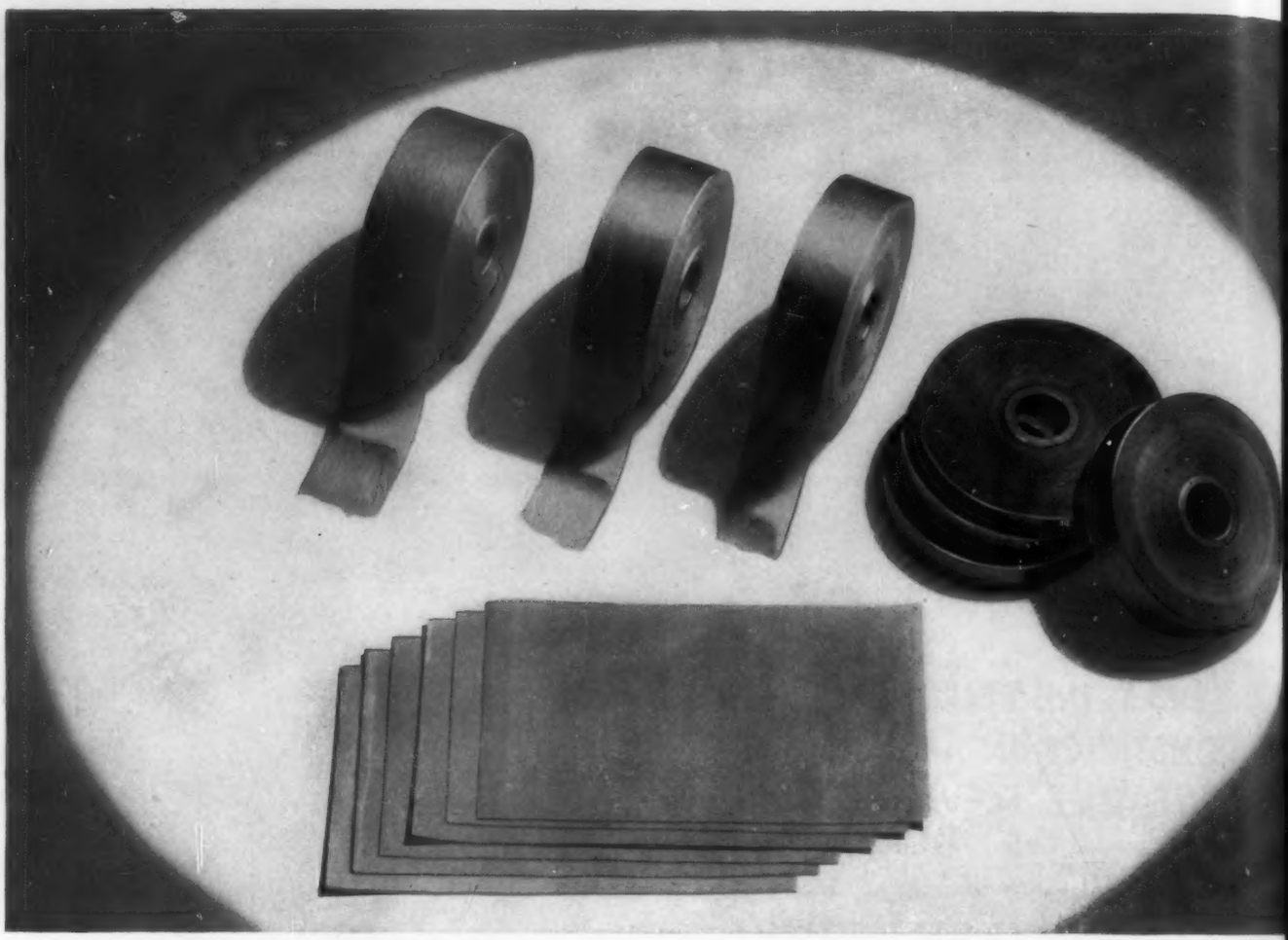
Every week 192,000 G-E employees purchase more than a million dollars' worth of War Bonds

GENERAL ELECTRIC

407-69-5700

Announcing

A NEW Dielectric Material for Capacitors--



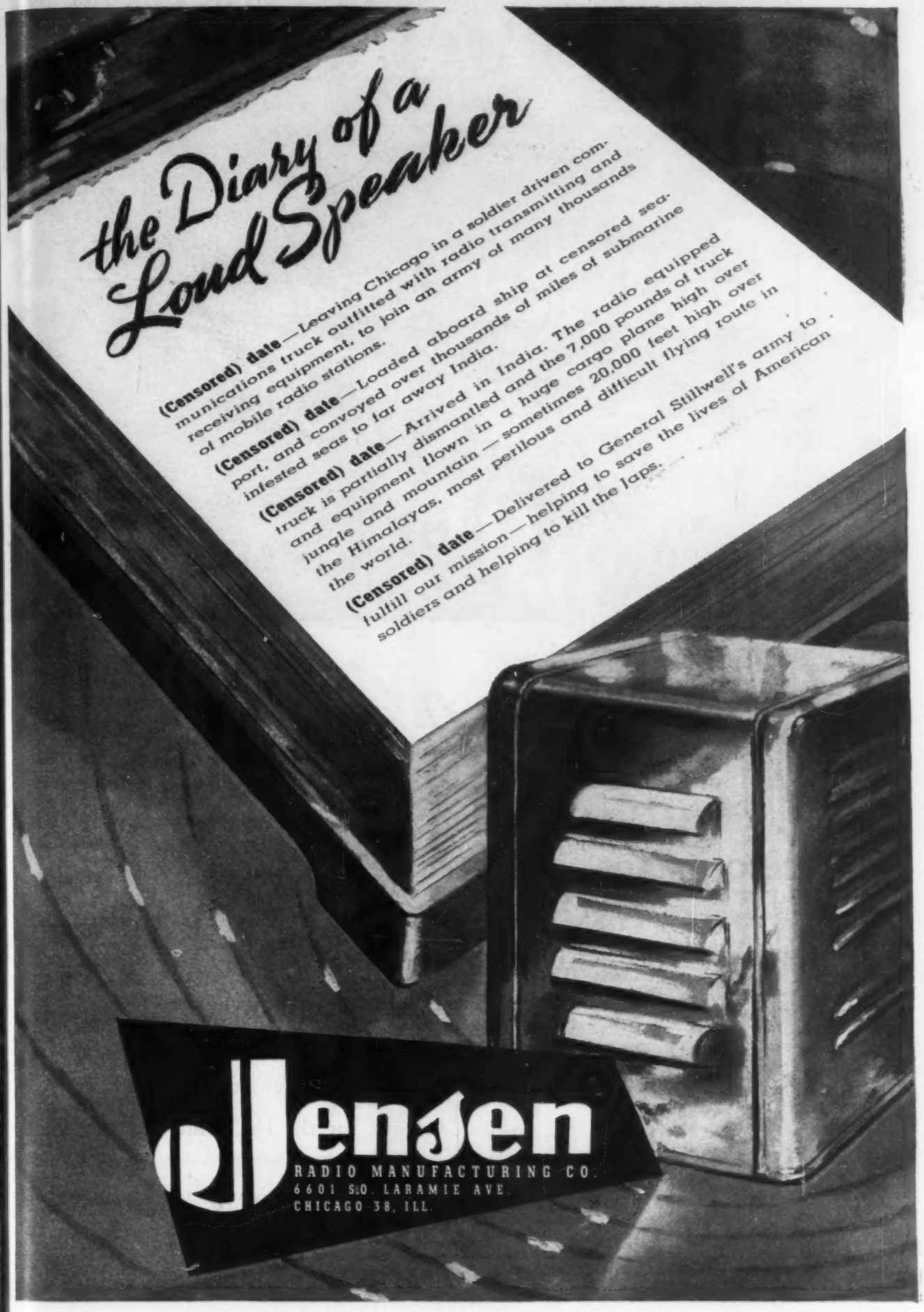
LECTROFILM—a new product developed by the General Electric Laboratories—is a synthetic dielectric made from raw materials that are available in large quantities in the United States.

Capacitor manufacturers will find it ideal for use in most radio-frequency-blocking and by-pass, fixed capacitors that for years have been built with mica. These capacitors are of the type used in communications and other electronic equipment.

Lectrofilm has a greater combination of desirable mechanical and electrical properties than any other one capacitor dielectric material. It is available in both rolls and sheets, and can be used in present capacitor production lines, little or no change being required in equipme or manufacturing methods. Its strength a flexibility make it well suited to handling automatic means.

Best of all, lectrofilm has uniform charact istics; it requires little if any grading, sortin or inspection. Therefore, it is economical well as easy to use, and when properly appli will cut down the number of finished capacit that are rejected in test. Users of lectrofi can expect increased capacitor producti with present facilities without any increase man-hours.

Lectrofilm is available for use by manufactur making capacitors for the armed forces.


the Diary of a Loud Speaker
(Censored) date—Leaving Chicago in a soldier driven communications truck outfitted with radio transmitting and receiving equipment, to join an army of many thousands of mobile radio stations.
(Censored) date—Loaded aboard ship at censored seaport, and convoyed over thousands of miles of submarine infested seas to far away India.
(Censored) date—Arrived in India. The radio equipped truck is partially dismantled and the 7,000 pounds of truck and equipment flown in a huge cargo plane high over jungle and mountain—sometimes 20,000 feet high over the Himalayas, most perilous and difficult flying route in the world.
(Censored) date—Delivered to General Stillwell's army to fulfill our mission—helping to save the lives of American soldiers and helping to kill the Japs.
Jensen
RADIO MANUFACTURING CO.
6601 S. O. LARAMIE AVE.
CHICAGO 38, ILL.

These are the BENEFITS of a CLOSELY HELD VOLTAGE SUPPLY

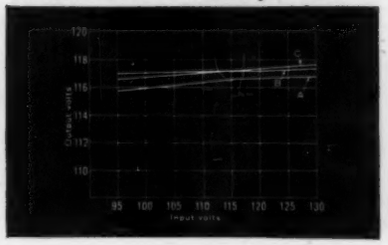
Better performance, greater reliability, and longer life of electronic devices

Protection of delicate instruments and machines, precision tools, and electronic tubes against sudden overvoltages

More accurate test results, fewer rejects

And manufacturers—don't forget:
A product's salability can be increased when voltage stabilization is a built-in feature.

EXTREMELY CLOSE VOLTAGE REGULATION, so essential to speedy, accurate production-line testing, is automatically maintained by a 500-volt-ampere G-E stabilizer on a test bench in a fluorescent-ballast factory.



▲ **LOOK AT THIS PERFORMANCE**—Practically constant voltage for several typical conditions (A—Open circuit; B—Full load, unity power factor; C—Full load, 0.8 power factor lagging). Stabilizing action practically instantaneous, taking place in less than three cycles.

...and Here's the Way to Get It

IMPROVES THE PERFORMANCE OF EQUIPMENT LIKE THIS:

Radio transmitters and testing equipment
Photoelectric equipment and other electronic-tube apparatus
Motion-picture projectors and sound equipment
Telephone apparatus
X-ray machines
Precision photographic equipment and photometers
Color comparators
Calibration of meters, instruments, relays
Laboratory precision processes and testing equipment

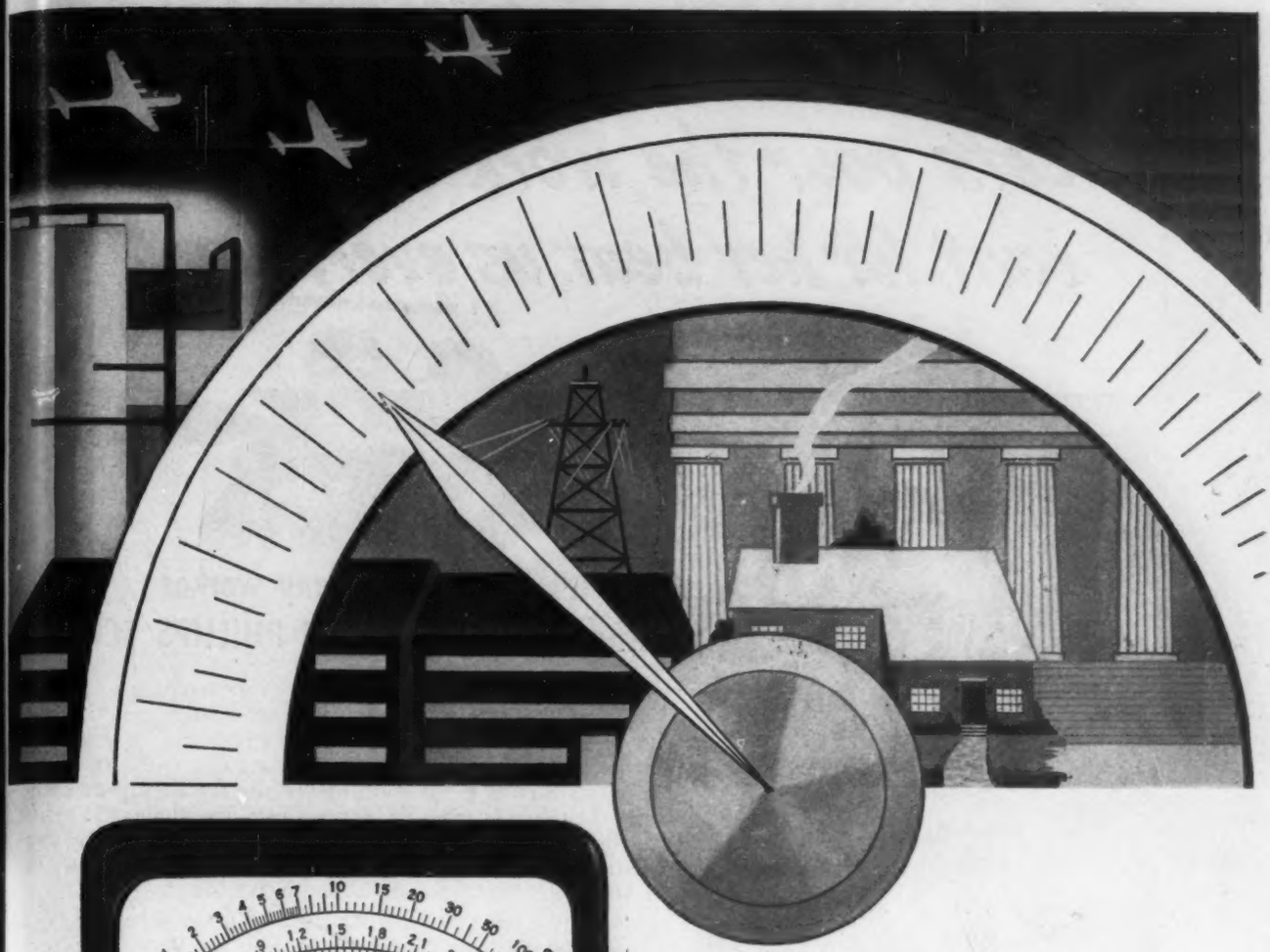
FOR DETAILS on this stabilizer's unique circuit, write for Bulletin GEA-3634. *General Electric Company, Schenectady, N. Y.*

VOLTAGE STABILIZERS

GENERAL ELECTRIC

408-53-5205

The best investment in the world is in this country's future—BUY WAR BONDS



THE ACCURATE WAY

There is only one way to take a measurement . . . **and *that* is the accurate way. In military, industrial, public service and home front applications, DeJur precision meters have proven themselves to be trustworthy instruments of measurement and control. Illustrated is an example of the many types of DeJur meters . . . specifications for individual requirements are invited.**

Insure a Better Postwar World by Buying More War Bonds Today

ARMY E NAVY

Awarded for Excellence in Production and Quality of Material

DeJur-Amsco Corporation

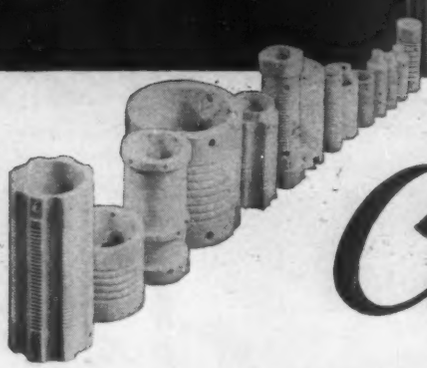
SHELTON, CONNECTICUT

NEW YORK PLANT: 99 Hudson Street, New York City • **CANADIAN SALES OFFICE:** 560 King Street West, Toronto

STUPAKOFF

FOUNDED IN 1899

Ceramics for the World of Electronics



Coil Forms

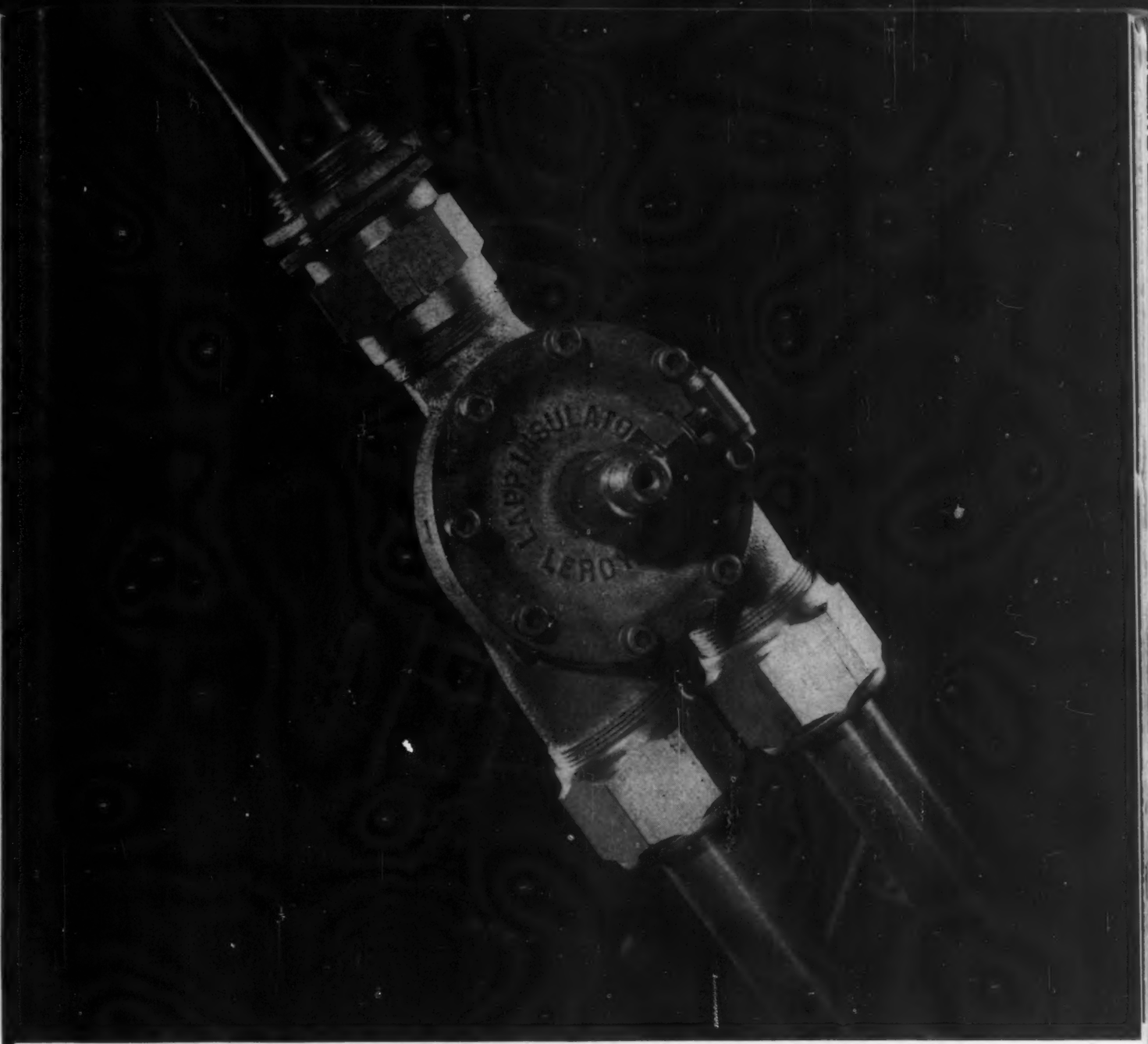
PRECISION MADE . . . of Steatite and other materials—glazed or unglazed—any size or shape—to your exacting specifications.

Years of experience—wide technical and engineering knowledge—modern manufacturing facilities enable STUPAKOFF to produce every type of ceramic for the electronic industry.

"for great achievement"

Back The Attack—With War Bonds

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.



Electronic Parts: ENGINEERING AND PRODUCTION

The gadget above is a junction box for a co-axial gas-filled transmission line. It is one of a series of coupling units, end seals and other fittings for high-frequency transmission—designed and built by Lapp.

To this type of construction, Lapp brings several innovations and improvements. For example, such a line from Lapp parts is genuinely leak-proof. Every gasket is under spring loading, so there's no leakage created by vibration or thermal change.

Whether or not you're interested in gas-filled transmission lines, you ought to know about Lapp. Here is an organization of engineers and manufacturers with broad basic knowledge of ceramics and their application. With experience in hundreds upon hundreds of special-purpose electronic parts, we have been able countless times to improve performance, or reduce costs, or cut production time through the application of our specialized skills to design and manufacture of parts involving porcelain or steatite and associated metal parts.

For quick and efficient assistance on a war production subcontract—or for the competitive advantage Lapp-designed and Lapp-built parts will give to you in the postwar battle—an inquiry to Lapp now may pay you dividends. *Lapp Insulator Co., Inc., LeRoy, N. Y.*

Lapp

ARMY E NAVY

"Let's pour the work on, chum—can't let her beat us everyday!"

. . . but it's hard to beat *any* worker who drives AMERICAN PHILLIPS SCREWS

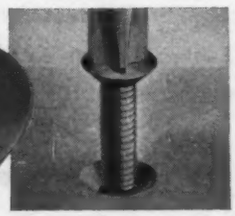
It's a fact . . . men have no easy time keeping their production ahead of women workers who have come in . . . *green* . . . and been broken into screw-driving assembly work with American Phillips Screws. For with American Phillips Screws there is no longer the forbidding differential in strength and skill between men and women . . . this modern method of screw driving is a common denominator that lifts the ability of the "weaker sex" to the productive level of the "stronger sex". And here's why:

All there is to do with American Phillips Screws is: (1) insert the Phillips driver in the Phillips Recessed Screw head. (2) Aim the driver with one hand and hold the work with the other. (3) Screw is automatically driven up straight and flush . . . without any effort to keep it straight. There's no premium on skill and strength, as with slotted screws. And the result: Production is increased as much as *twice* where American Phillips Screws are used. And there are no scarred hands, no scarred work, no broken screw heads . . . because the Phillips driver *can't slip out.*

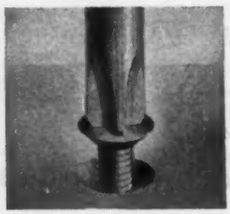
In addition, there are other advantages to the use of American Phillips Screws which come from the name American: Full Value, guaranteed by self-checking count and individual inspection. American Engineering, that gives you expert help on special fastening problems. And American Service, that gives reasonably prompt delivery even in war time.

AMERICAN SCREW COMPANY
PROVIDENCE, RHODE ISLAND

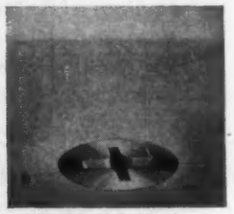
Chicago: 589 E. Illinois Street *Detroit:* 5-267 General Motors Building



1. Fast Starting—Driver point automatically centers in the recess . . . fits snugly. Screw and driver "become one unit." Fumbling, wobbly starts are eliminated.



2. Faster Driving—Spiral and power driving are made practical. Driver won't slip out of recess to injure workers or spoil material. (Average time saving is 50%.)



3. Better Fastenings—Screws are set up uniformly tight, without burring or breaking heads. A stronger, neater job results and there are no gouges on work-surface.

There's More to Engineering than Design

It's one thing to concentrate the combined forces of research and engineering on a problem, and thereby come up with the answer—and quite another thing to put that answer into mass production on an assembly line.

This teamwork between research engineering and mass production is a Delco Radio specialty, developed through years of experience in the exacting manufacture of peacetime automotive radios. It is being applied to highly intricate wartime assignments which include volume production of receivers and transmitters for mobile artillery and tanks . . . straight-line assembly of push-button tuning for vehicular radio receivers . . . mass manufacture of relays, plugs, receptacles, rotary switches, shock mountings . . . and volume production of components for air-borne communication and electronic navigation equipment.

Today, when the ability to discover and design must be teamed with the ability to produce in great quantity with highest quality, Delco Radio finds itself well prepared for wartime industry's needs. Delco Radio Division, General Motors Corporation, Kokomo, Indiana.

Back Our Boys By Buying Bonds!

Delco Radio
DIVISION OF
GENERAL MOTORS

Don't lie awake nights . . .

. . . worrying about the countless intricacies involved in the design of new electronic devices. Don't worry, that is, unless you also are planning to use the best electronic tubes. For, just as a bridge must be strong enough to meet all the demands of the traffic it is intended to carry — so electronic tubes must be carefully chosen to perform perfectly. Raytheons are engineered to meet the most rigid requirements.

RAYTHEON TUBES, long known and respected by manufacturer and radio servicemen alike, are being specified more and more by advanced electronic engineers and designers whose vital projects demand the finest in tubes.

FOUR "E" AWARDS FOR EXCELLENCE
Each Division of Raytheon has been Awarded the Army and Navy "E"

RAYTHEON

RAYTHEON MANUFACTURING COMPANY
Waltham and Newton, Massachusetts

DEVOTED TO RESEARCH AND THE MANUFACTURE OF TUBES AND EQUIPMENT FOR THE NEW ERA OF ELECTRONICS

"BREADBOARD" or Flying Doughboys

Behind the scenes in Precision Aircraft Radio Manufacture... One of a series. Kodachrome by BR Photo.

The device in this picture is known as a "breadboard"... but instead of kneading dough this young woman is weaving the warp and woof of the wiring system for a Bendix* Aircraft Radio Compass.

This harness entails hundreds of separate wires woven into place, cut to connect *exactly* with 1200 terminals, with every inch in exact position, ready for assembly.

Here at Bendix Radio the deft fingers of many women are fashioning these tapestries of war... one of the thousands of vital operations involved in the volume production of Bendix Radio electronic equipment for aircraft.

Bendix Radio "know-how" and specialized experience in the design of complete electronic systems, assure the superior performance of Bendix Radio Equipment on every war front . . . as in civilian air travel, today and tomorrow.

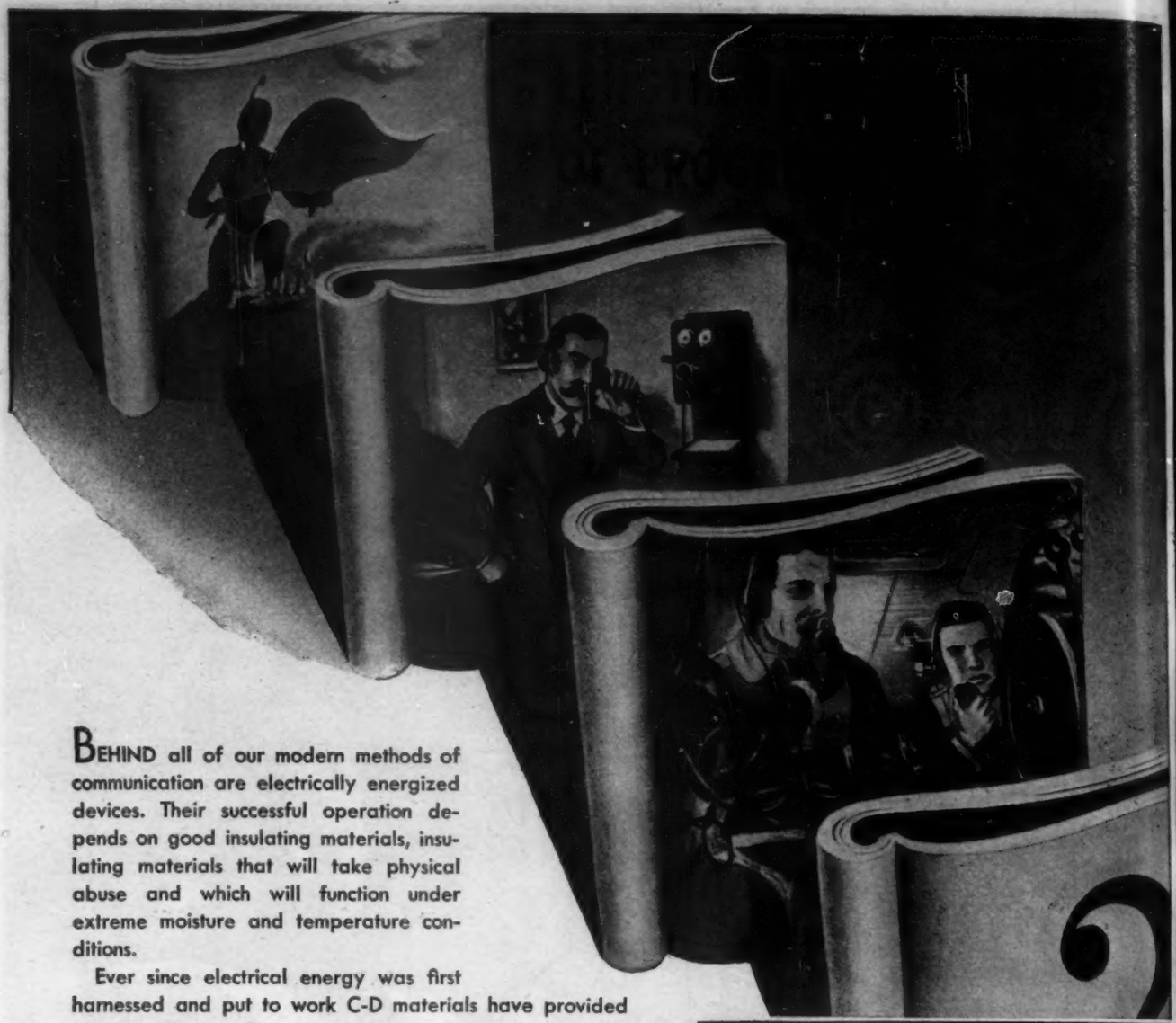
THE INVISIBLE CREW

Precision Equipment by **Bendix Aviation Corporation**

*TRADE MARK OF BENDIX AVIATION CORPORATION

BENDIX RADIO

BENDIX RADIO DIVISION OF THE BENDIX AVIATION CORPORATION



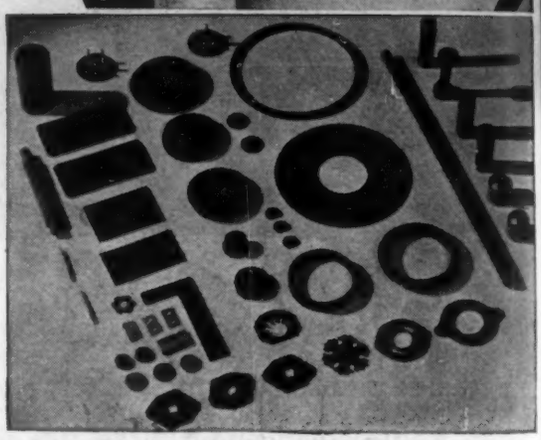
BEHIND all of our modern methods of communication are electrically energized devices. Their successful operation depends on good insulating materials, insulating materials that will take physical abuse and which will function under extreme moisture and temperature conditions.

Ever since electrical energy was first harnessed and put to work C-D materials have provided good insulation. The development of better insulating materials has been the constant goal of the C-D laboratory. The success of C-D's efforts have been the lengthening shadows which have forecast the phenomenal advances which this country has made in the field of communications.

1st DIAMOND Vulcanized FIBRE; then DILECTO, a moisture proof insulation; 3rd VULCOID, which combines to a remarkable degree the desirable properties of both DIAMOND Fibre and DILECTO; 4th MICABOND—Mica insulation in its most usable form and now DILECTENE, a pure resin plastic especially for U-H-F insulation.

C-D engineers have helped solve thousands of insulating problems. They have accumulated a wealth of "know how" which is at your disposal to help solve your electrical insulation problem.

DISTRICT OFFICES: New York • Cleveland • Chicago • Spartanburg, S. C. West Coast Rep., Marwood, Ltd., San Francisco • Sales Offices in principal cities



C-D products include THE PLASTICS... DILECTO—a laminated phenolic: CELORON—a molded phenolic: DILECTENE—a pure resin plastic especially suited to U-H-F insulation... THE NON-METALLICS, DIAMOND Vulcanized Fibre: VULCOID — resin impregnated vulcanized fibre: and MICABOND—built-up mica insulation. Folder GF describes all these products and gives standard sizes and specifications.

CH-43

Continental - Diamond FIBRE COMPANY

Established 1895 . . Manufacturers of Laminated Plastics since 1911 — NEWARK • DELAWARE

"NEVER BE SATISFIED WITH MEDIOCRITY"

From telegraph boy to head of the world's largest plant producing automatic radiotelegraph apparatus . . . is Ted McElroy's* own success saga. And the creed that drove him on—NEVER BE SATISFIED WITH MEDIOCRITY. This same spirit prevails throughout the McElroy organization where inquisitive engineers never copy and never imitate. They create, design, build . . .

Typical of the work they do is the new McELROY MODEL SR-900 SL-990 . . . a superior commercial recorder including an automatic noise limiter and signal leveller. Embodying new principles of design and operation, it will record clean, readable signals at speeds up to 350 words a minute under the most adverse conditions.

Your inquiries are invited. If a McElroy engineer can be of service to you, ask for one.

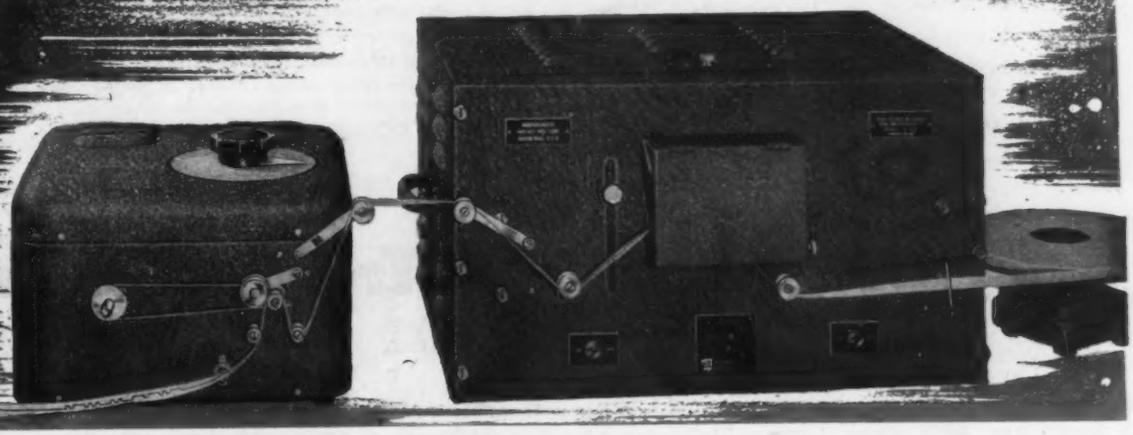
*WORLD CHAMPION RADIO TELEGRAPHER FOR MORE THAN 20 YEARS

McElroy MANUFACTURING CORP.
82 BROOKLINE AVE., BOSTON, MASS.

WORLD'S LARGEST MANUFACTURER OF AUTOMATIC RADIO TELEGRAPH APPARATUS

BUY MORE WAR BONDS

ARMY E NAVY



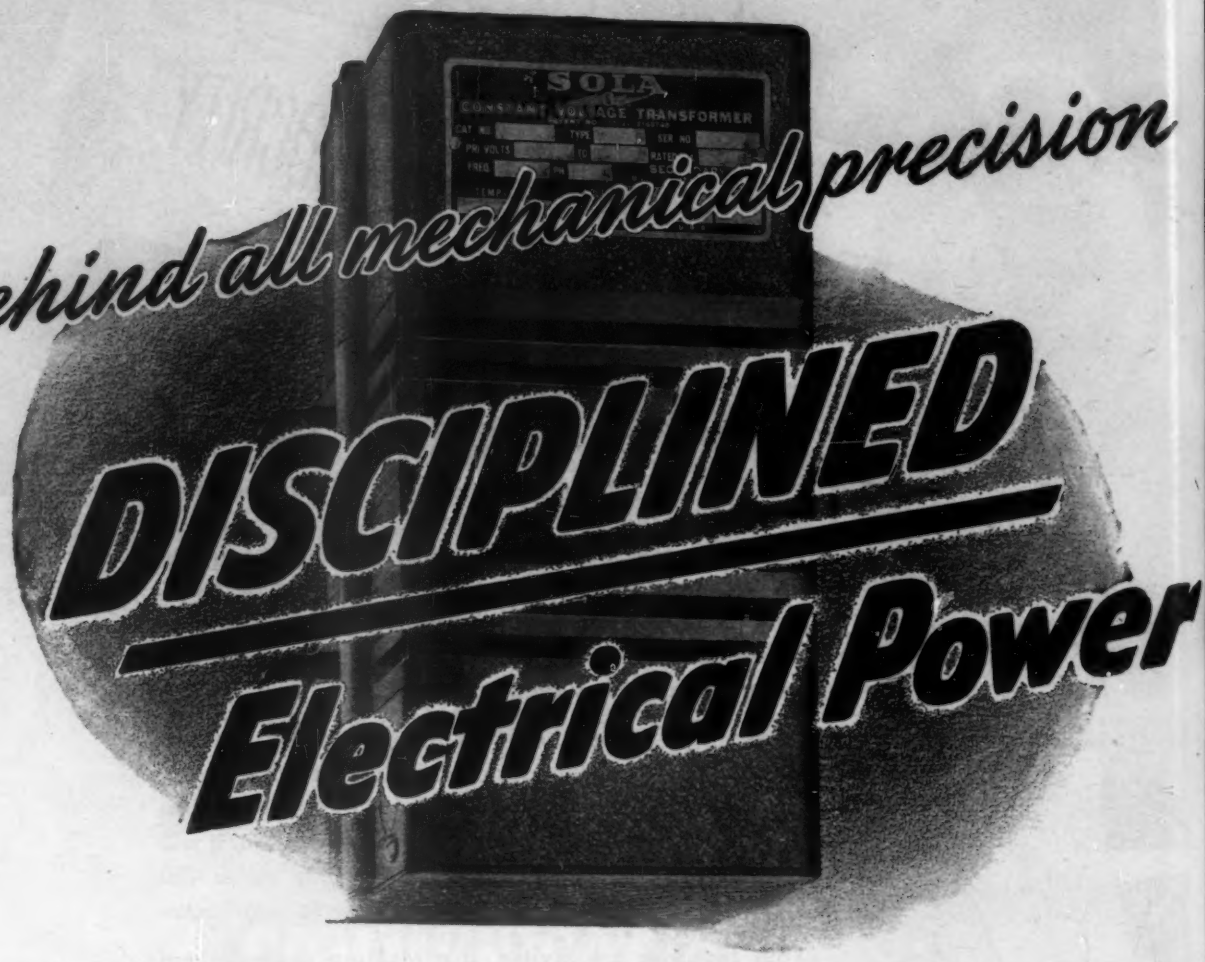
COMMUNICATIONS EQUIPMENT

WAR-TESTED Precision for Post-War Performance

On far-flung battlefields—in the air—on the sea, equipment produced by Sherron is serving importantly in the drive toward victory. Under the most exacting conditions—where failure is fatal—this equipment is demonstrating, to vital manufacturers and utilities, Sherron's high standards of performance.

To Manufacturers—For war or postwar needs we offer an exceptional combination of facilities . . . Engineering, Design, Manufacturing, Assembly, Complete Production to Specifications. (Single units or quantities.)

SHERRON METALLIC
CORPORATION
1201 FLUSHING AVENUE • BROOKLYN, NEW YORK



Behind all mechanical precision

DISCIPLINED Electrical Power

WHEN EACH SMALL PART, as it comes from the machine—each finished article, as it comes from the assembly line—*varies not at all* from the others, the problems of QUALITY production have been solved, and QUANTITY production presents small difficulty.

Modern electrically operated manufacturing equipment is expertly designed to produce with *absolute exactness*. That's the miracle behind today's output. *But*, the mechanical perfection of each individual unit must be matched by an unfailing, unvarying power supply. Every unit, however small, must be responsible for its own security. That is why SOLA Constant Voltage Transformers are widely used to provide protection against damaging voltage variation.

Where this control is lacking, electrically operated or controlled equipment is highly vulnerable to voltage fluctuations. Devices designed to operate at rated voltages *react differently* to drops or increases in voltage. Then uniform accuracy and synchronization of the production line no longer exists. Precision work becomes impossible. Rejects increase in number.

SOLA "CVs" protect equipment and instruments, absorbing voltage sags and surges up to 30% and deliver an unchanging, specific voltage regardless of input variations from over-loaded supply lines.

Automatic and instantaneous in action, SOLA "CVs" allow no jolts or sags to slip through. They are made with the same modern exactitude as the most intricate equipment. Immediately available in standard units, capacities from 10 VA to 15 KVA, SOLA Constant Voltage Transformers can also be built to your specification.

Note to Industrial Executives: *Where there is a problem involving voltage control, no matter what its nature, SOLA "CV" Transformers can help solve it. Ask for bulletin DCV-74.*

SOLA Constant Voltage Transformers

Transformers for: Constant Voltage • Cold Cathode Lighting • Mercury Lamps • Series Lighting • Fluorescent Lighting • X-Ray Equipment • Luminous Tube Signs • Oil Burner Ignition • Radio • Power • Controls • Signal Systems • Door Bells and Chimes • etc. **SOLA ELECTRIC CO., 2525 Clybourn Ave., Chicago, Ill.**

NEW PLASTIC INSULATING GROMMETS

#3/P-231

ALL HOLES ARE CONCENTRIC

#3/P-232

ALL CORNERS CHAMFERED

#3/P-234

ALL THREADS CLEAN & LUBRICATED

#3/P-233

ALL PARTS MATTE FINISH

Of special interest to production engineers seeking to cut down assembly time operations, Creative's new line of 100% phenolic plastic insulating grommets offers many important advantages. These new grommets, available in four standardized sizes, have been developed especially for use by Radio, Electronic Generator, Dynamotor, Aircraft and other manufacturers. Holes are concentric, with all corners chamfered, avoiding wire chafing. All threads are clean and lubricated. To promote easy gripping and reduction of assembly time all parts are matte finished.

Electrically, Creative grommets are ideal. For example, dielectric strength averages about 260 to 430 v.p.m.; dielectric constant 5.5 to 7.4; power factor at 10^6 cycles .02 to .05. Water absorption is unusually low at only .5% in 24 hour test.

Creative grommets, available from stock, are sold at prices which reflect mass production efficiency

SEND FOR SAMPLE CARD

AND PRICE LIST NOW

Creative Plastics Corp.

978 KENT AVENUE BROOKLYN 5, NEW YORK

NEW YORK • CHICAGO • LOS ANGELES • LONDON • HAVANA

On Winning a Star . . .

They "Did the Impossible Ahead of Schedule." Group of Workers in the Hicksville Plant of Press Wireless, Inc., Rejoicing at Announcement The Plant Had Been Given Its Second Army-Navy "E" Award.

Press Wireless, Inc., takes pleasure in announcing that its plant at Hicksville, Long Island, has received a second Army-Navy award for outstanding achievement in the production of essential radio equipment for war purposes and has been given the starred pennant symbolizing this distinction.

To meet a certain standard such as is required to be eligible for the "E" award is one thing; to maintain that standard and improve upon it over a period of months is another. For accomplishing both, Press Wireless, Inc., is justly proud of the men and women of its Hicksville plant.

At this stage of the war, steadfast adherence to high manufacturing standards is vital. Press Wireless, Inc., pledges continuation of such standards along every sector of its production front.

PRESS WIRELESS, INC.

Sales Office, Manufacturing Division
1475 BROADWAY, NEW YORK CITY

Executive Offices
435 N. MICHIGAN AVENUE, CHICAGO

RIO DE JANEIRO • MONTEVIDEO • BERNE • SANTIAGO DE CHILE

"We vibrate, 'em, too, Miss Gadfly . . . . ."

Miss "Tiny" Gadfly, impelled and inspired by the vision of a svelte, girlish figure, oscillates in phase with the vibrations of "Little Gem." With like determination, but with a different scientific purpose, Hytron tubes are also vibrated vigorously.

A motor-driven eccentric arm mercilessly agitates the tube while a sensitive vacuum-tube voltmeter discloses the slightest variation in the a.c. component developed across the plate load resistor. An imperfect weld—a loose element—a potential short circuit—these, and other trouble-makers are instantly detected.

Tubes which pass this standard Hytron factory test are not likely to fail. When subjected to the ruthless throbbing of machines of war by fighting men too intent on a battle for survival to baby them, these tubes "get the message through."

BUY ANOTHER WAR BOND

OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

HYTRON CORPORATION ELECTRONIC AND RADIO TUBES

SALEM AND NEWBURYPORT, MASS.

HYTRON RADIO TUBES

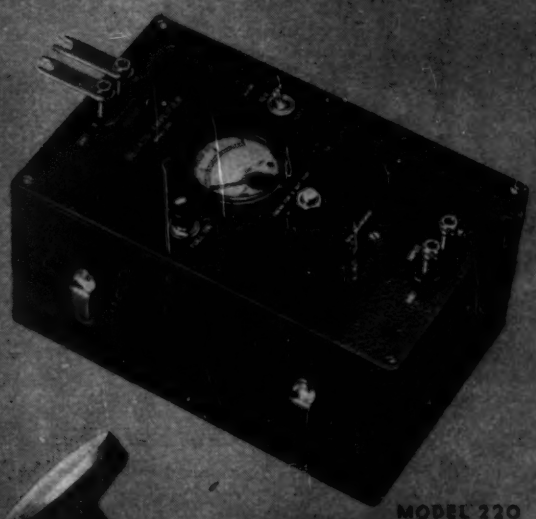
BALLANTINE
AC VOLTMETER

MODEL 300
ELECTRONIC
VOLTMETER

Although designed for the usages of peace thousands of these instruments are now rendering conspicuous wartime service in Government, commercial and university laboratories, factories and maintenance depots all over the world.

MODEL 402
MULTIPLIER

MODEL VP-5
VIBRATION PICKUP



MODEL 220
DECADE AMPLIFIER

0.00002 TO 10,000 VOLTS

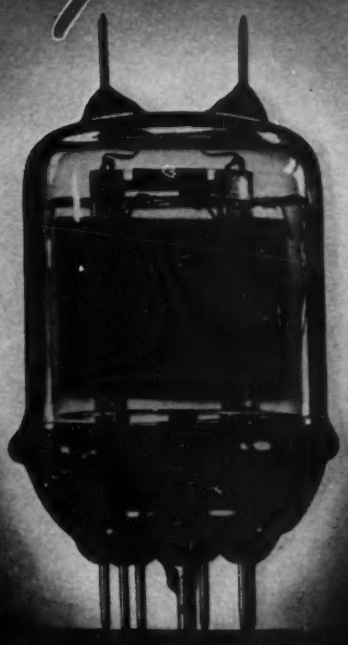
This enormous range of voltages—five hundred million to one—is accurately covered by our Model 300 Electronic Voltmeter and some of the accessories shown above. Frequency range 10 to 150,000 cycles. Accuracy 2% over most of the range. AC operation. Five decade ranges with logarithmic scale make readings especially easy. Uniform decibel scale also provided. May also be used as a highly stable amplifier, 70 DB gain, flat to 150,000 cycles.

BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY

ANSWER

to an Engineer's Prayer



WHEN WAR began, among products high on the "critically needed" list were N. U. power tubes. To operate thousands of field and ship transmitters, these tubes were needed in quantities which called for vastly increased facilities *plus some entirely new thinking along mass production lines.*

With a thoroughness that could not miss, National Union engineers went to work on this assignment. Soon they not only had the increased volume required—but in addition we had found the answer which many a tube engineer and production man had long sought, even prayed for... the Tube Industry's first automatic exhaust and sealing machines to operate successfully with this type of tube.

Such resourcefulness and engineering capacity have played no small part in making National Union one of the Tube Industry's largest producers of war goods. For improved types of tubes and installation data to keep their post-war business in step with electronics progress, service engineers can *count on* National Union.

National Union Radio Corporation, Newark, N. J.

Factories at Newark, N. J.; Maplewood, N. J. Lansdale, Penna.; Robesonia, Penna.

NATIONAL UNION

RADIO AND ELECTRONIC TUBES

Transmitting, Cathode Ray, Receiving, Special Purpose Tubes • Condensers • Volume Controls • Photo Electric Cells • Panel Lamps • Flashlight Bulbs

WEIGHT REDUCTION PROBLEMS?

In designing radios for combat service, every ounce counts. Weight reduction is not only an engineering problem—it becomes a matter of fighting efficiency. Westinghouse engineers have co-operated with many designers to work out a variety of solutions, of which the accompanying illustrations are typical examples.

Perhaps these are directly applicable to your problem; or it may be that yours is completely different. In either case, trained and experienced Westinghouse representatives are ready to help you; call them today. Westinghouse Electric & Manufacturing Company, Dept. 7-N, East Pittsburgh, Pennsylvania. J-94565

*Registered Trade-mark Westinghouse Elec. & Mfg. Co.

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Hipersil*, the new Westinghouse magnetic steel for transformer cores, increases flux-carrying capacity ½ and reduces weight 30 to 50%.

For aircraft and airborne radio, blower and motor combined for maximum air circulation in a weight-saving magnesium housing.

Inerteen capacitors deliver more microfarads per ounce.

INSULATION

Tuffernell, Glasweve and mica insulating materials permit high operating temperatures and consequent savings in weight.

Westinghouse

PLANTS IN 25 CITIES...OFFICES EVERYWHERE

CRAFTSMANSHIP
In nearly a half century of manufacturing electro-mechanical components, Chicago Telephone Supply Company has gained world-wide recognition.
Throughout these years, manufacturers have become accustomed to the high quality workmanship and downright dependability of Chicago Telephone Supply products.
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Manufacturers of Quality Electro-Mechanical Components Since 1896

THROUGH ELECTRONICS

we knew it would be a nice day for a boat ride

Man's ability to forecast weather is close-knit with his whole economics of living.

Electronics in the form of the Radiometeorograph is the modern method of collecting weather data. Carried by a small balloon high above the earth and there released by parachute, the Radiometeorograph sends out radio impulses that accurately indicate atmospheric conditions at given points. An analysis of many such reports gives your weatherman a basis for accurate predictions.

The Electronic Tube is the heart of the Radiometeorograph. Such tubes are built by TUNG-SOL. Other TUNG-SOL tubes of all types are helping to supply the vital needs of our armed forces. After the war a new and complete line of TUNG-SOL tubes will be available for civilian uses. Right now TUNG-SOL engineers will gladly assist in the planning and development of post-war electronic devices.

TUNG-SOL

vibration-tested

ELECTRONIC TUBES

TUNG-SOL LAMP WORKS, INC., NEWARK, NEW JERSEY

Sales Offices: ATLANTA, CHICAGO, DALLAS, DENVER, DETROIT, LOS ANGELES, NEW YORK

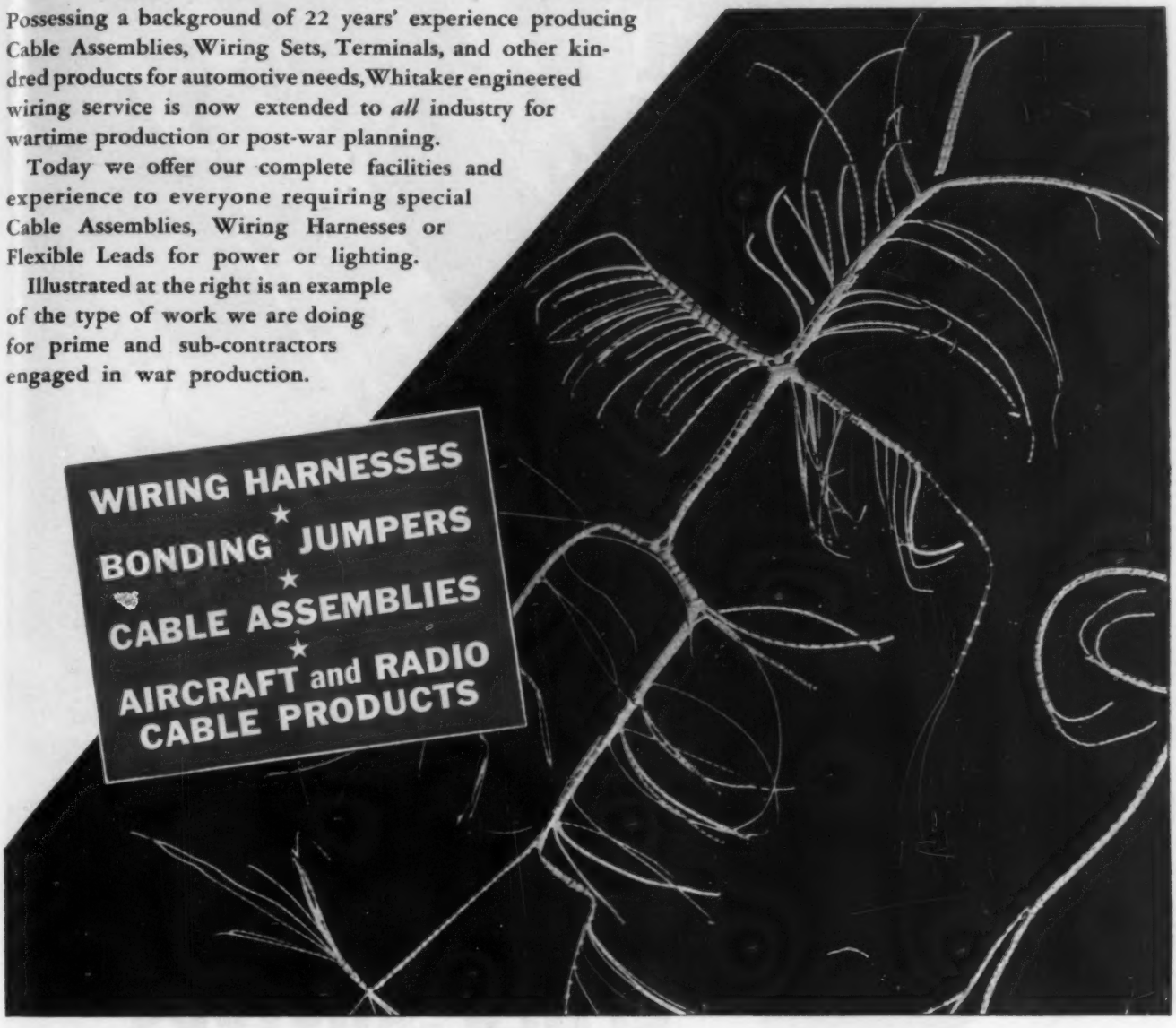
ALSO MANUFACTURERS OF MINIATURE INCANDESCENT LAMPS. ALL-GLASS SEALED BEAM HEADLIGHT LAMPS AND CURRENT INTERMITTORS

Whitaker Can Wire It

Possessing a background of 22 years' experience producing Cable Assemblies, Wiring Sets, Terminals, and other kindred products for automotive needs, Whitaker engineered wiring service is now extended to *all* industry for wartime production or post-war planning.

Today we offer our complete facilities and experience to everyone requiring special Cable Assemblies, Wiring Harnesses or Flexible Leads for power or lighting.

Illustrated at the right is an example of the type of work we are doing for prime and sub-contractors engaged in war production.



Keeping pace with war needs of today and with industrial progress for tomorrow, Whitaker has complete facilities for producing Wiring Harnesses, Bonding Jumpers, Cable Assemblies, and Flexible Leads.

We cordially invite you to advise us of your needs. Send us a wiring diagram or blueprint of the assembly required, and our engineers will give the problem immediate attention.

Years ago we recognized that speed with quality is essential to getting the job done. Investigate and you will find that Whitaker *can* help your production by taking over your wiring problems.

WHITAKER BATTERY SUPPLY COMPANY
Kansas City, Mo. • St. Joseph, Mo. • Philadelphia • Oakland

WHITAKER

Cables, Wiring Harnesses and Assemblies for Automotive, Aircraft, Marine and Radio Equipment

..is making *electronic* BLOCK-BUSTERS

A design problem holding up some war project in electronics is no less important than a strategic enemy stronghold which must be blasted out of action. Immediate and skillful handling is essential.

Seemingly insuperable difficulties, such as climate, weight, shock, vibration, moisture, etc., assume an almost routine status at N-Y-T. Unusual frequency characteristics, critical limits on distributed capacity, immunity to surges, special shielding and regulation requirements find speedy solutions under constant testing, devising and experimentation.

Electronic "block-busters" will be needed in the post-war period, too. The N-Y-T Sample Department will be available for such assignments.

NEW YORK TRANSFORMER COMPANY

26 WAVERLY PLACE **NEW YORK, 3, N. Y.**

An Award and An Acknowledgment

The Employees of The Rola Company Inc., now wearers of the Army-Navy "E", wish to acknowledge a debt... and express a word of appreciation... to certain people outside the Rola organization. They are far too numerous to mention by name but they include:

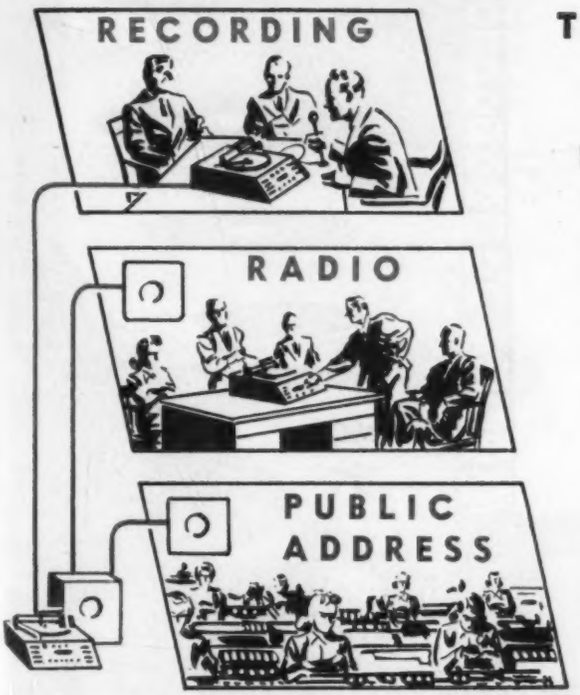
- *The Personnel of the Army and Navy Air Forces with whom we have worked.*
- *The Prime Contractors who have entrusted us with orders.*
- *The Suppliers of our equipment and materials.*
- *The Transportation Companies who have handled our shipments.*
- *The many others on whom we have had to depend.*

To all those at home who have *helped* us, and to our former associates, now in the armed services, who have *inspired* us, we express our deep gratitude... and with them we proudly share the honor of this Award.
The Employees of THE ROLA COMPANY INC., Cleveland, Ohio.

ROLA

MAKERS OF THE FINEST IN SOUND REPRODUCING AND ELECTRONIC EQUIPMENT

Radiotone



THE ONLY UNIT THAT *Gives You All 3*

It is a high-fidelity professional recorder combination which includes a microphone recorder, radio recorder, radio, phonograph and public address system. It can be equipped with any number of loud speakers or used in conjunction with your present P. A. system.

DEALERS CAN PARTICIPATE NOW!

In the distribution of Radiotone to essential industries, including schools and other institutions... as well as the complete line of Radiotone accessories including recording discs and needles. Write for catalog and complete details.

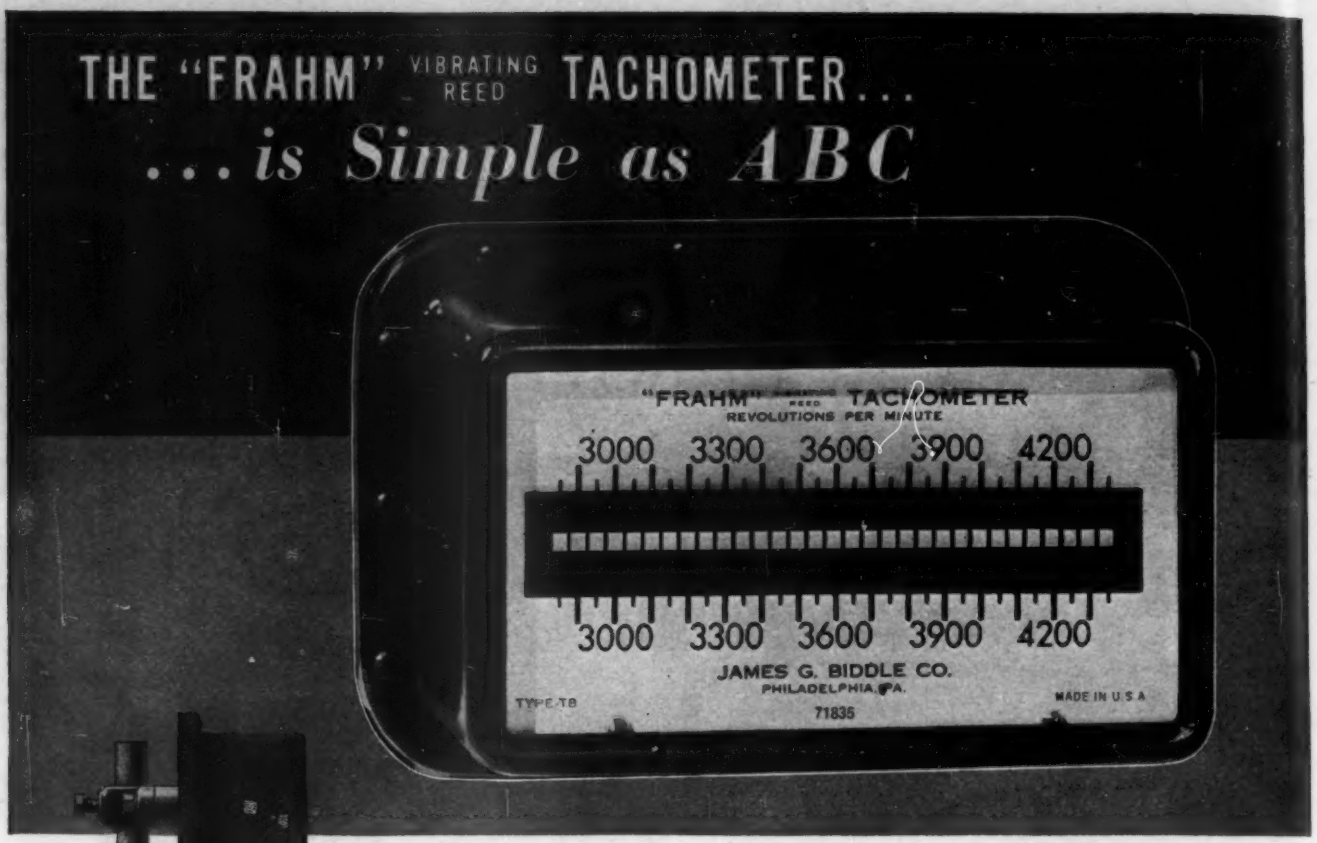
Radiotone

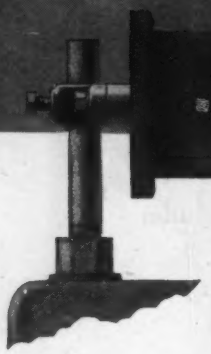
Division of
THE ROBINSON HOUCHIN OPTICAL CO.
Columbus, Ohio

Hollywood, 7356 Melrose Ave. ★ SHOWROOM AND SALES OFFICE, 1811 Chestnut St., Philadelphia

THE "FRAHM" VIBRATING REED TACHOMETER...

...is Simple as A B C





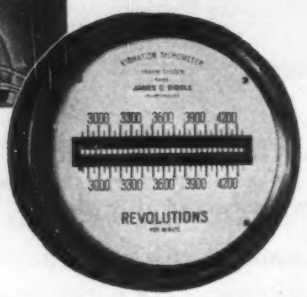
Above: Showing one method of mounting the Frahm Tachometer.

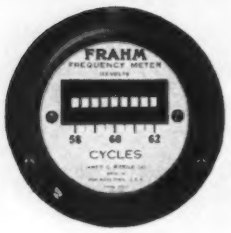
●

Below, left: Frahm Hand Tachometer.

●

Below, right: Frahm Permanent Mount Tachometer.





Consider the inherent simplicity of a tachometer that need only be mounted on or held in contact with the machine. It means:

No belts, flexible shafts, gears, or electrical connections.

No lubrication required; No maintenance.

Independence from any outside source of power.

And the Frahm Tachometer is as accurate as it is reliable. It functions faithfully without attention year after year because there are no delicate parts—no springs, jeweled bearings, pivots, weights, magnets or connecting wires—nothing except a set of steel reeds, accurately calibrated and suitably mounted.

Furnished in stationary and portable types . . . for use on turbines, generators, motors, blowers, centrifugal pumps, Diesel-electric installations, etc. Various ranges available from 900 to 30,000 r.p.m.

For a complete description of Frahm Tachometers, together with list of types and ranges commonly supplied, write for Bulletin 1590-E.

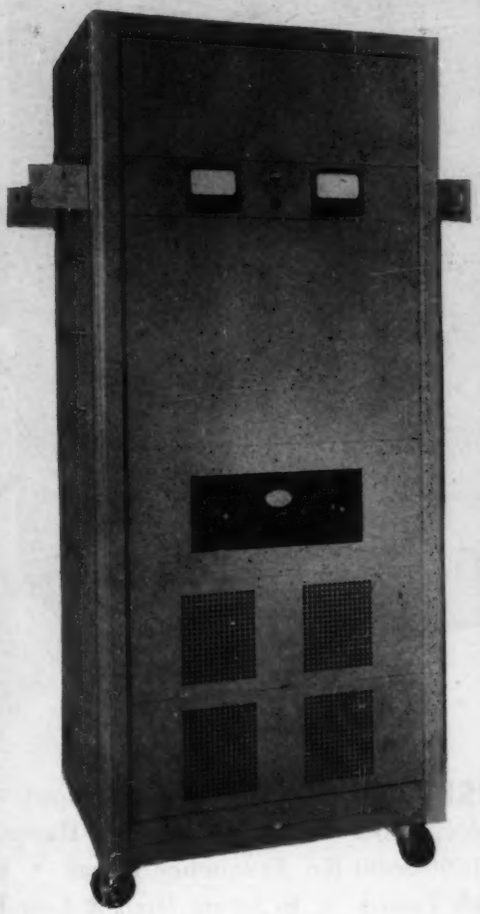
●

"FRAHM" VIBRATING-REED FREQUENCY METERS—operate on the same unique principle as Frahm Tachometers, except that reed vibration is produced electrically instead of by direct mechanical contact. Unaffected by wave form or ordinary temperature changes. Switchboard, portable and miniature types in various ranges from 10 to 500 cycles per second. Write for Bulletin 1695-E.

JAMES G. BIDDLE CO.

1211-13 ARCH STREET • PHILADELPHIA 7, PA.

DO YOU NEED D.C. AMPERES?



TO attract your attention we use this picture of a large rectifier. But we also make small ones, either Selenium disc or tube. The size is always determined by design requirements.

WE engineer and custom build complete RECTIFIER UNITS to meet the needs of *any* industrial or laboratory application.

Your problem may call for high current, low or medium voltage, or you may need high voltage and low current.

Selenium disc rectifiers will take care of one—Electronic tubes the other. *We have both.*

Each type of rectifier excels for certain work and it is our job to engineer and build equipments to meet your particular needs.

May we apply our engineering skill and construction experience to your D.C. needs?

Write L. W. Reinken, Chief Engineer

W. GREEN ELECTRIC COMPANY, INC.

GREEN EXCHANGE BLDG., 130 CEDAR ST., NEW YORK 6, N. Y.

RECTIFIER ENGINEERS

EST. 1892

GOULD-MOODY "BLACK SEAL" GLASS BASE INSTANTANEOUS RECORDING BLANKS . . .

RECORDING AMERICA'S *POWERFUL* VOICE

Transmitter of America's Powerful Voice is Radio . . . awake twenty-four hours a day . . . talking to our friends and our enemies . . . transporting Broadway and Hollywood and the girl next door to the boys over there . . . building morale on the home front.

Recording America's Powerful Voice . . . in leading broadcasting stations from coast-to-coast . . . are Gould-Moody "Black Seal" Glass Base Instantaneous Recording Blanks. Made entirely of glass, "Black Seals" are as thin as aluminum, thereby eliminating the necessity of recorder adjustments. No foreign inserts . . . no metal grommets . . . no ageing, hardening or deterioration. Every disc has four holes . . . center-flow thread action . . . may be played back for months without appreciable loss of fidelity. Enclosure of your preference rating extensions with your order will expedite deliveries.

SHARE YOUR BLOOD WITH A WOUNDED SOLDIER
—donate a pint to the Red Cross today

THE GOULD-MOODY COMPANY

RECORDING BLANK DIVISION — 395 BROADWAY, NEW YORK 13, N. Y.

PROVEN, PRETUNED Dependability

MODEL 425

MARINE
RADIO TELEPHONE

Advantages

COMPLETE CRYSTAL CONTROL • NO TUNING DIALS • FIVE CHANNEL OPERATION • ONE FREQUENCY CHANGE CONTROL • EFFICIENT D. C. POWER SUPPLY • ISOLATED GROUND POTENTIAL • WALL OR TABLE MOUNTING • THREE CHASSIS CONSTRUCTION • CABINET HINGES FORWARD • FRONT PANEL REMOVABLE • EASY TO INSTALL & SERVICE • COMPLETE ACCESS TO INTERIOR WHILE IN OPERATING CONDITION

Features

←**TRANSMITTER** • Full 25 Watts Output—All Channels • Capable 100% Modulation • Low Harmonic Radiation • 1600-3600 Kc. Frequency Range • Five Channels—Each Tuned • Separate High & Low Frequency Circuits.

←**RECEIVER** • High Sensitivity Superheterodyne • Complete Crystal Control • Five Channels—Each Pretuned • Frequency Range 2180 to 3600 Kc. • Adjustable Squelch Circuit • Effective Noise Limiter.

←**POWER SUPPLY** • 6 V., 12 V. or 32 V. D. C. Operation • Quiet-Dependable Dynamotor • Adequately Filtered • Chassis Removable • Capable Continuous Operation • D. C. Voltages Isolated From Ground.

Send for Descriptive Literature

Designed and Manufactured By

RAY JEFFERSON, INC.

Manufacturer Communications Equipment

40 East Merrick Road, Freeport, L. I., N. Y.

ESSENTIAL REQUIREMENT

THE essential requirement of an ideal electronic connection is a sound electrical joint assuring constant, low resistance value, regardless of operating and atmospheric conditions. ¶ It is met by STA-KON* (Solderless) Wire Terminals. ¶ When properly applied to the wire with a T&B Hand or Power Tool, these T&B Pressure Connectors become an integral part of the wire itself. ¶ They are made in any desired design of tongue and in wire sizes #22 to 250 MCM AWG. ¶ We invite electronics manufacturers to consult our engineering service on unusual wiring problems. ¶ STA-KONS, like the thousands of other T&B electrical fittings, are sold only through recognized T&B Distributors who reduce the manufacturer's selling costs, thereby reducing the cost of all electrical material to the user.

WRITE FOR DETAILED, ILLUSTRATED STA-KON BULLETIN 500

* Patented STA-KON: Reg. U. S. Pat. Off.

THE THOMAS & BETTS CO.

INCORPORATED

MANUFACTURERS OF ELECTRICAL FITTINGS SINCE 1899

ELIZABETH 1, NEW JERSEY

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E Flag awarded April, 1943
White Star awarded October, 1943

A DECAL WIRING DIAGRAM IS ALWAYS THERE!

Wiring diagrams in the form of Meyercord Decalcomania serve the armed forces on a wide variety of strategic combat equipment. Engineered to withstand grueling atmospheric conditions of the Tropics, the Arctic, the Stratosphere, Meyercord Decal diagrams stay "put". While easy to apply, they eliminate the danger present in "easy-to-come-off" paper and glue type diagrams. Complete immersion will not destroy their legibility or adhesion. They are washable, durable, vibration proof, and can be produced in any size, design or colors.

Wiring diagrams, stowage charts and spare parts listings are but a few of the thousands of war uses for Meyercord Decalcomania. Their use for nameplates, instructions, insignia, etc., on combat vessels, tanks, planes, communication and other fighting equipment saves time, money, weight and metal. Send for complete literature. Address your inquiries to Department 912.

Speed Victory - Buy War Bonds

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SUPPLIERS OF BOMBARDERS TO VACUUM TUBE MANUFACTURERS SINCE 1921

HEATING, PLUS!

As early as two decades ago SCIENTIFIC ELECTRIC Bombarders have found wide application in the removal of occluded gas from vacuum tube elements. Later, this highly specialized equipment was extensively used in metallurgical research. Today, the improved Bombarders are standard equipment in a diversity of induction heating applications, and

SCIENTIFIC ELECTRIC KEEPS PACE!

Offering complete collaboration in problems pertaining to induction heating, high frequency and high voltage test equipment, custom built to conform with strict government specifications, SCIENTIFIC ELECTRIC invites your inquiries.

SCIENTIFIC ELECTRIC
DIVISION OF
"S" CORRUGATED QUENCHED GAP COMPANY
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TINNING · ANNEALING · BRAZING · DENYDRATING · BONDING · BOMBARDING · NORMALIZING · SURFACE HARDENING · MELTING · HEAT TREATING

A NEW, IMPROVED 872-A

We are now in quantity production on this better 872-A Tube and can supply to Army, Navy specifications. It is a medium power Rectifier, 10,000 volt inverse peak. Extensively used for power supplies from 1,000 to 5,000 volt output. Current output . . . 2 tubes 2½ amperes.

1 Domed type anode. No sharp surfaces to concentrate discharge. Rolled edges and thoroughness with this permits high temperatures used in evacuating tube preventing local overheating.

2 Ribbed can also with no sharp edges to concentrate discharge. High temperatures also possible due to mechanical construction.

3 Glass bead eliminates discharge from anode stem and lengthens operating life.

4 Sturdy filament construction with unusually large emission surface permitting an exceedingly low voltage drop in tube. Ceramic support prevents filament distortion, thus controlling mutual heating effects and providing long filament life.

5 Bottom closed shield plate prevents excess heat where leads come through glass stem, insures freedom from gas leads, a common cause of tube failure.

GENERAL ELECTRONICS INC.

Chicago: 1917 No. Springfield Ave.
Export Dept. — 89 Broad St., N. Y. C.

101 HAZEL STREET, PATERSON, N. J.

NEW BH FIBERGLAS SLEEVING

Cuts Without Spreading—

Fuzzes but Doesn't Fray

Flexible as String

You've waited a long time for a sleeving that was *both* flexible and non-fraying. Now it's here—BH Extra Flexible Fiberglas Sleeving.

As an example of the hundreds of uses for this new product, let's look at a typical brush shunt job. Sleeving for this application should be flexible. When cut to length, the ends should not fray or spread. Formerly, brush manufacturers stiffened the ends of the sleeving to prevent fraying and also to facilitate threading onto the pigtail. BH Extra Flexible Fiberglas cuts cleanly without spreading, eliminates the extra dipping operation. Furthermore, in service the ends do not fray. Constant vibration produces only the slightest fuzz. Yet even these are but a few advantages of this new sleeving.

NON-FRAYING • FLEXIBLE • HEAT-RESISTANT
NON-INFLAMMABLE • WATER-RESISTANT
NON-CRYSTALLIZING at LOW TEMPERATURES

The new BH Extra Flexible Fiberglas Sleeving is woven from the choicest continuous-filament Fiberglas yarns. It possesses high dielectric strength, is water-resistant and, like all BH Sleeving and Tubing—is non-inflammable.

All sizes, from No. 20 to 5/8", inclusive, are available. Write for samples of this radically new and different sleeving today—in the sizes you desire. Seeing is believing! Bentley, Harris Manufacturing Co., Dept. E, Conshohocken, Pa.

BH PRODUCTS

NON-BURNING IMPREGNATED MAGNETO TUBING • NON-BURNING FLEXIBLE VARNISHED TUBING • SATURATED AND NON-SATURATED SLEEVING

BENTLEY, HARRIS MANUFACTURING CO.
Conshohocken, Penna.

GUARD Your Screw Driving Army Against Injury and Absence

PHILLIPS SCREWS ARE SKID-PROOF!

No hand-injuries from skidding screw drivers! That's the protection against absenteeism you can get by using Phillips Recessed Head Screws. The scientifically designed Phillips Recess automatically centers the driver in the screw head . . . utilizes full turning power . . . and "brakes" the driver against skidding!

Safe, faultless screw driving no longer means slow output. Old hands and new, alike, work faster and surer with Phillips Screws. There are no fumbling, wobbly starts . . . slant-driven screws . . . or burred and broken screw heads. Spiral and power driving are made practical. In literally thousands of plants, replacement of slotted-head screws by Phillips Screws has increased screw driving speed up to 50% . . . and has entirely eliminated rejections due to driver gouges.

Compare the costs of driving Phillips and slotted head screws. You'll find that it actually costs less to make fastenings with Phillips Recessed Head Screws!

KEY TO FASTENING SPEED AND SAFETY

The Phillips Recessed Head was scientifically engineered to afford:

Fast Starting – Driver point automatically centers in the recess . . . fits snugly. Screw and driver "become one unit." Fumbling, wobbly starts are eliminated.

Faster Driving – Spiral and power driving are made practical. Driver won't slip out of recess to injure workers or spoil material. (Average time saving is 50%.)

Easier Driving – Turning power is fully utilized by automatic centering of driver in screw head. Workers maintain speed without tiring.

Better Fastenings – Screws are set-up uniformly tight, without burring or breaking heads. A stronger, neater job results.

PHILLIPS *Recessed Head* SCREWS

WOOD SCREWS • MACHINE SCREWS • SELF-TAPPING SCREWS • STOVE BOLTS

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The Bristol Co., Waterbury, Conn.
Central Screw Co., Chicago, Ill.
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Pheoll Manufacturing Co., Chicago, Ill.
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Russell Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
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The Southington Hardware Mfg. Co., Southington, Conn.
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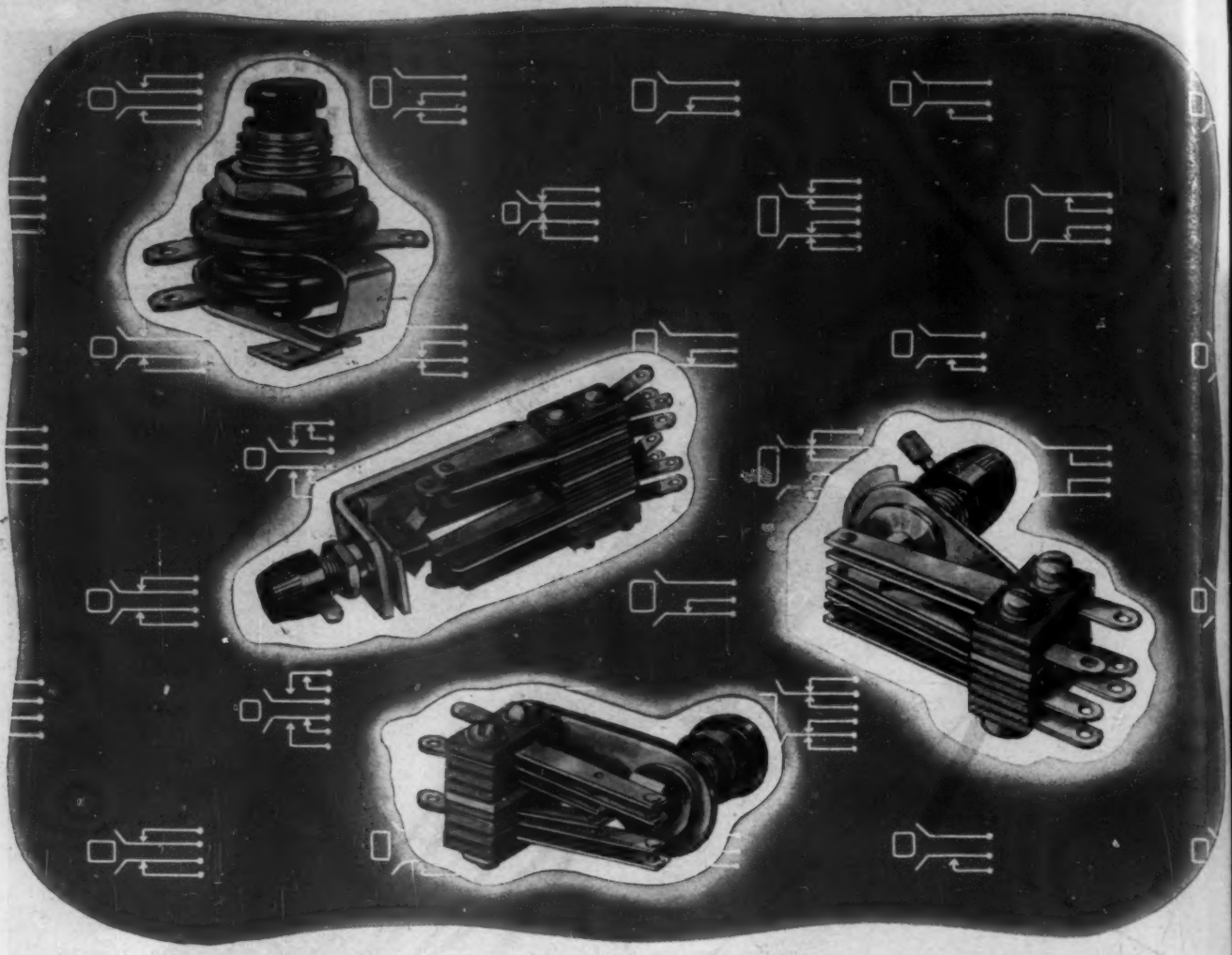

FOR TOP EFFICIENCY AT THE KEY-POINT IN A CIRCUIT

UTAH SWITCHES EVERY TIME!

Where the human element and mechanical perfection must combine to provide top performance, insist on Utah Switches. They are time-tested in hundreds of electrical applications in industrial plants and on far-flung battle-fronts.

There's a Utah Switch for virtually every circuit

UTAH Switches are made to fit your electrical and space requirements. Compact size, highest quality material and precision manufacture make Utah Switches everything a switch should be. Utah "Imp" push-button switches have the finest nickel silver or phosphorus bronze springs with integral contacts. Springs are fully insulated from the mounting bushing. High-grade phenolic insulation is used. They are available in three circuit arrangements: "single make," "single break," one "break make."

Also available are Utah Rotary and push-button jack switches, in long and short types. Small and compact in size, they are made to take minimum panel space. Full insulation is provided for all electrical parts.

Take advantage of Utah's extensive electrical and electronic experience. Write today for full information on Utah switches.

UTAH RADIO PRODUCTS COMPANY, 837 Orleans St., Chicago, Ill. Canadian Office: 560 King St. West, Toronto. In Argentine: UCOA Radio Products Co., S. R. L., Buenos Aires. Cable Address: UTARADIO, Chicago.

PARTS FOR RADIO, ELECTRICAL AND ELECTRONIC DEVICES, INCLUDING SPEAKERS, TRANSFORMERS, VIBRATORS, VITREOUS ENAMELED RESISTORS, WIREWOUND CONTROLS, PLUGS, JACKS, SWITCHES, ELECTRIC MOTORS

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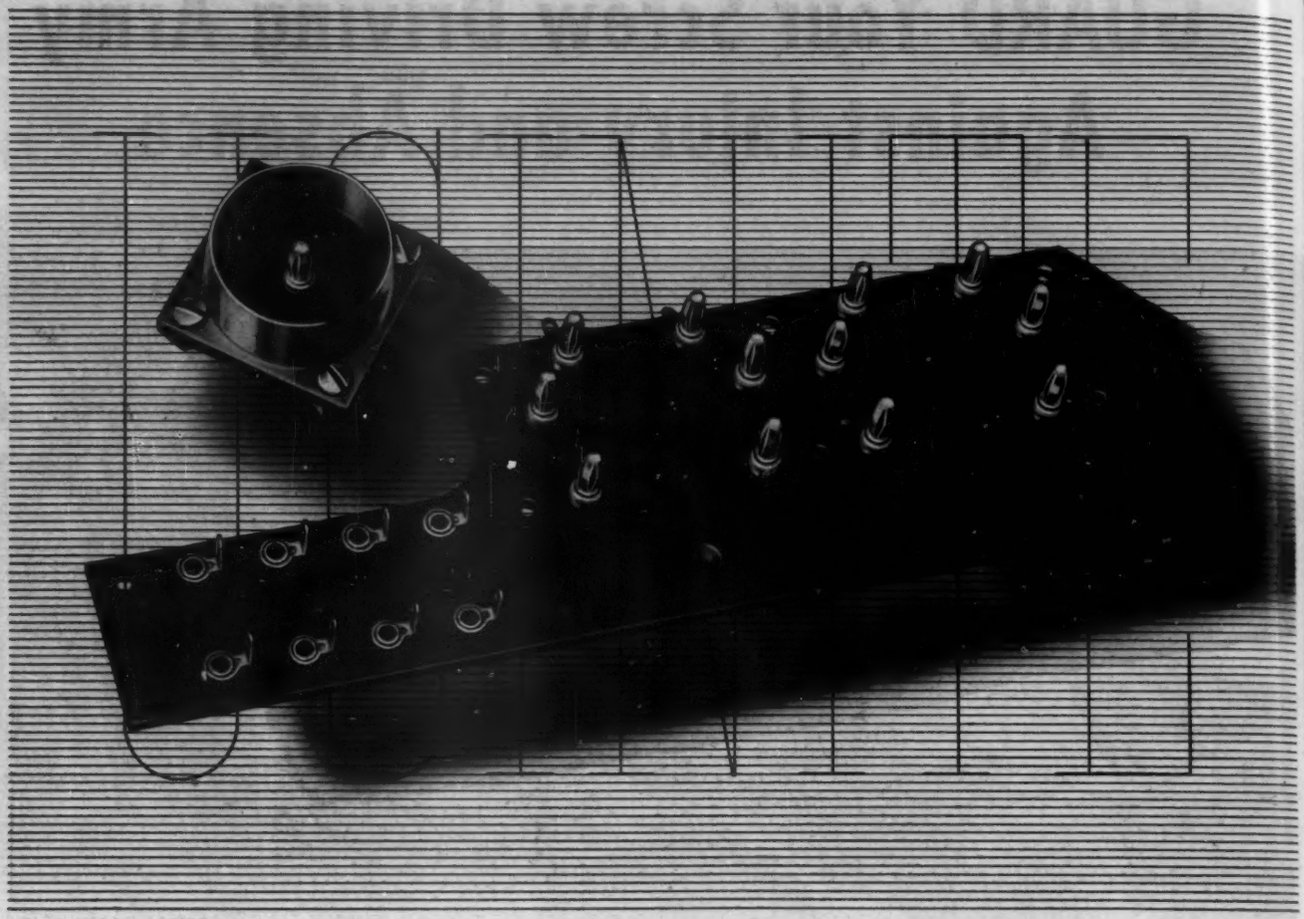


Up our alley

Banana pins are one of our basic products at Ucinite. Turning them out in large quantities is a run-of-the-mill job for us. We do it, nevertheless, with unfailing accuracy and care.

We can design banana pin assemblies for your particular needs and produce them — from start to finish — under one roof and one management.

Small jobs get the same attention at Ucinite as the big ones. We have the staff as well as the capacity to take them all in stride.

The UCINITE CO.

Newtonville 60, Mass.

Division of United-Carr Fastener Corp.

Specialists in **RADIO & ELECTRONICS**

LAMINATED BAKELITE ASSEMBLIES

CERAMIC SOCKETS • BANANA PINS & JACKS • PLUGS • CONNECTORS • ETC.

C-D RESEARCH DEVELOPED IT

radio engineers accept it as a symbol of efficiency and dependability in high power mica capacitors

TO THE PERSISTENCE OF CORNELL-DUBILIER RESEARCH IN CAPACITORS, CREDIT SUCH DEVELOPMENTS AS...

Low loss, glazed ceramic cylindrical case

- minimum physical size for safe rating
- eliminates corona troubles
- impervious to climatic conditions
- mechanically sturdy

Patented series mica stock

- eliminates corona
- uniform voltage gradient
- uniform loading
- low losses

Cast aluminum end-cap terminals

- low resistance contacts
- permit space-saving mounting for series, parallel and series-parallel connections

Special low-loss filler

- reduces stray field losses
- protects against humidity
- no air voids

Type 59 Mica Transmitting Capacitor typical of Cornell-Dubilier reliability, proven time and again under severe operating conditions.

In 1910 William Dubilier produced his first transmitting capacitor. Thirty-three years of persistent research, and exacting production standards have made C-D the insignia of outstanding quality. Next time you specify capacitors, remember, there's good reason for this fact: there are more C-D capacitors in use today than any other make. Inquiries welcomed. Cornell-Dubilier Electric Corporation, South Plainfield, New Jersey.

Cornell Dubilier Capacitors

The importance of Lumarith* (cellulose acetate base) plastics in the electrical field is a well-established fact. In film . . . foil . . . and molded form, it guards against *electro-chemical* corrosion — brings the equivalent of "free-air" protection to delicate electrical circuits.

The illustration on this page shows Lumarith* in another application—putting its transparency, dielectric properties and toughness to full use. These test pliers are constructed to handle the "hot jobs" without danger of short circuits. The husky service man can bear down heavily—Lumarith* has the flexural strength to stand up to his grip without breaking. Thus, Lumarith* steps in to do a job where the brittleness of many of the other plastics resulted in too much breakage.

Molded by Kuhn and Jacob Moulding & Tool Co. Trenton, N. J. for Star Fuse Co., Inc., New York City.

You are invited to draw upon our documented experience and laboratory data for both your short-range and long-range planning. Celanese Celluloid Corporation, The First Name in Plastics, *a division of the Celanese Corporation of America, 180 Madison Avenue, New York City 16.*

Lumarith*

A CELANESE PLASTIC

*Reg. U. S. Pat. Off.

Only 2½%* of the war plants have won this honor...

THIS flag is a war medal for outstanding performance of duty in the production of vital war equipment. It is a tribute to the men and women in the -*hp*- organization and a tribute to the excellence of the products of their efforts. -*hp*- instruments are today actually engaged in the business of war. You'll find them in the factories where valuable war equipment is being built, in the military services where this equipment is kept functioning at peak, in the laboratories where new tools of war are being perfected. Every individual at -*hp*- is proud to become a member of small elite group of organizations in the U.S.A. who have been honored in this manner.

*Approximately 2½% August, 1943

HEWLETT-PACKARD CO.

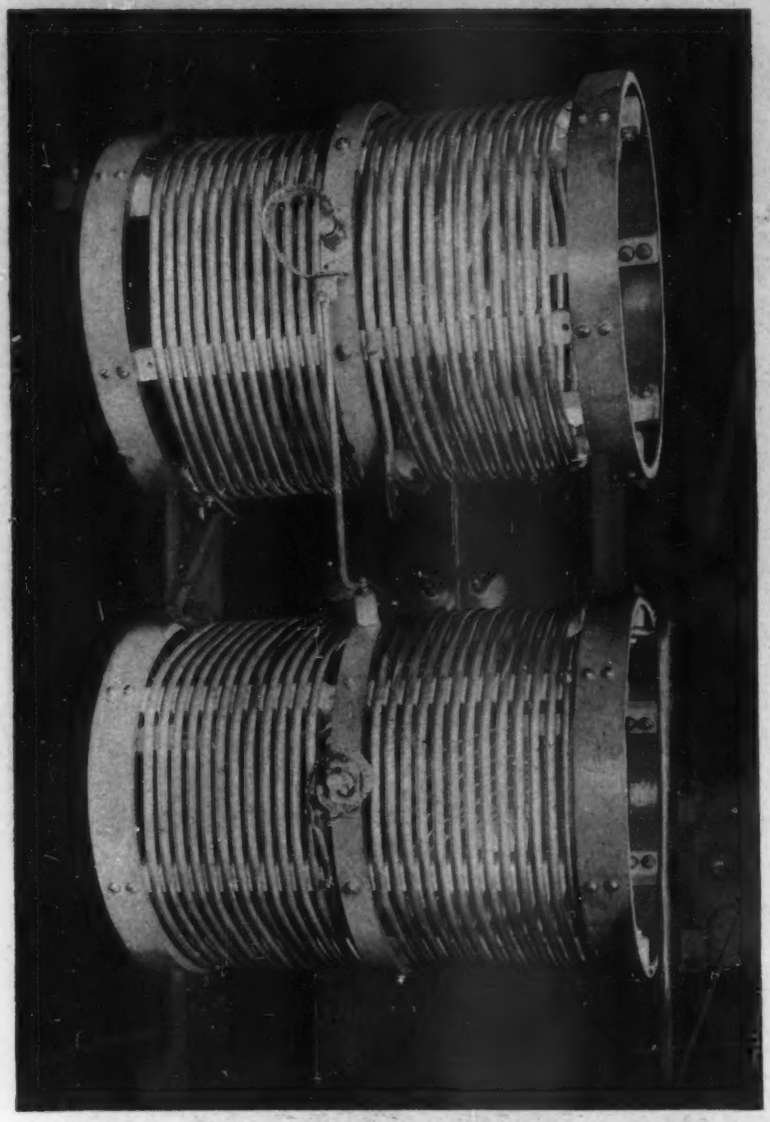
Laboratory Instruments for Speed and Accuracy

PALO ALTO, CALIFORNIA

hp

How Good

are Bunnell Transmitters?



Well, we don't make the biggest transmitters. And we don't make the most.

But every one we build is especially designed for its special purpose. And every detail of every part of every transmitter must be meticulously correct.

Call it idealism. Or perfectionalism. It's good business for us. And better performance for you!

JHB SINCE 1878

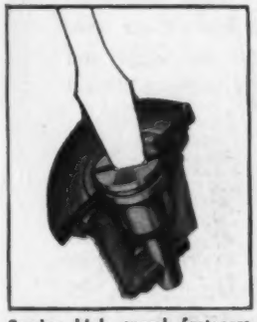
J. H. BUNNELL *& Co.*

GENERAL OFFICES: 215 Fulton St., New York City · FACTORIES at Brooklyn, N. Y.

Designing Engineers and Manufacturers of:

ELECTRONIC INDUSTRIAL DEVICES ★ INDUSTRIAL RECTIFIERS
HIGH POWER RADIO FREQUENCY GENERATORS ★ TRANSMITTERS
RECEIVERS ★ AUTOMATIC TELEGRAPH EQUIPMENT

ASSURANCE



Camloc high speed fasteners operate with a quarter turn of the screwdriver. They secure doors and access panels in metal, plastic or plywood.

Stud Assembly is easily inserted or removed as a unit. Selection of correct size at final assembly allows for cumulated tolerances. Cross pin is permanent.

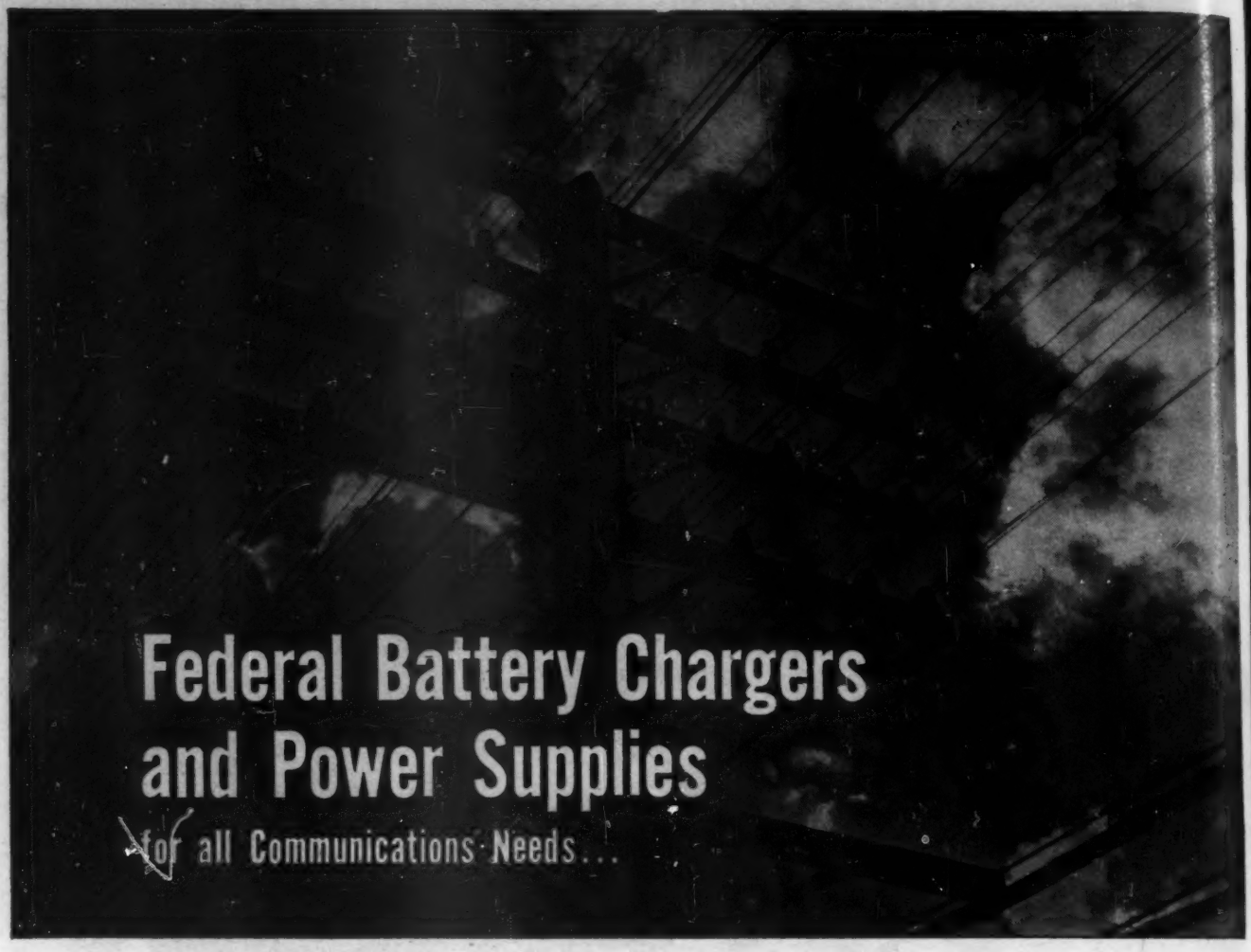
A complete line permits selection of Cam Collar exactly suited to the application. Floating type allows up to 1/8" alignment in any direction.

CAMLOC'S stud head clearly visible 1/8" above the panel indicates that the fastener is unlocked. A flush stud head gives assurance that Camloc has secured firmly, the members to which it is attached. Many such unique features make Camloc High Speed Fasteners an important part of today's fighting aircraft. Camloc eagerly awaits the day when this modern method of securing doors and access panels will be available to peacetime products of metal, plastic and plywood. Write for catalog.

CAMLOC *high-speed* FASTENERS

CAMLOC FASTENER CORPORATION, 420 LEXINGTON AVE., NEW YORK 17, N.Y. • 5410 WILSHIRE BLVD., LOS ANGELES

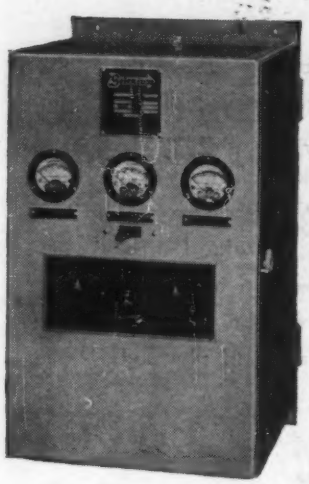
Copr. 1943, Camloc Fastener Corporation



Federal Battery Chargers and Power Supplies

for all Communications Needs...

. . . powered by I. T. & T. Selenium Rectifiers



Typical Automatic Noiseless Telephone Battery Charger

Built for highest efficiency and powered by long-life I. T. & T. Selenium Rectifiers, Federal Battery Chargers and Power Supplies are available in all types and sizes, in a wide range of ratings, to meet every communications requirement — telephone, telegraph, signaling and alarm systems. The many types include automatic regulated noiseless chargers and battery eliminators, manually operated units and non-filtered types.

Federal Battery Chargers and Power Supplies provide important operating advantages: no routine maintenance; no radio interference; hum-free output; high overall efficiency. They are for use on commercial AC circuits; they are rugged and compact and have a minimum of critical materials.

The "power unit"—the I.T.&T. Selenium Rectifier introduced and manufactured by Federal — is standard in the electrical field. Its freedom from moving parts, its wide temperature operating range, its capacity for overload and unlimited life, assure stable and satisfactory performance. *Consulting engineering services available from Department H.*

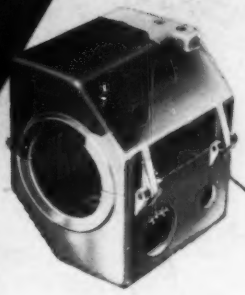
Federal Telephone and Radio Corporation

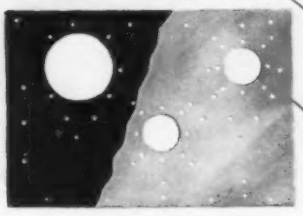
SELENIUM RECTIFIER DIVISION

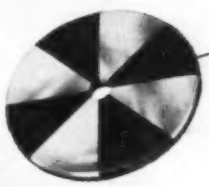
AN IT&T ASSOCIATE

1000 Passaic Ave.
East Newark, New Jersey

METAL PLATING *on Plastics*







WHAT IS THE METAPLAST PROCESS?*

It is a process for electroplating a smooth non-porous adhesive metal coating in any desired thickness, on non-conductive surfaces. Various metals or methods of plating can be used to insure one or a combination of desired properties of high conductivity, resistance to vibrational stresses, dimentional stability and elimination of moisture absorption.

WHAT ARE SOME APPLICATIONS?

A popular application of Metaplating is shown in the above photograph of a silver plated loop antenna. Metaplating provides a strong feather weight shield to eliminate precipitation static and to increase the "Q" of the loop.

Also shown is a thirty inch antenna mast used on combat planes. It is built of Compreg Wood and Metaplated with copper to Signal Corps specifications.

Pictured also is an electrostatically shielded housing Metaplated with a base coat of copper and finished with cadmium for corrosion resistance. Weight and expensive machine work are eliminated by the use of a light plastic for this complicated housing.

Easily printed and weight saving plastics can be used for instrument panels by Metaplating on the back any desired thickness of metal for grounding or electrostatic shielding.

The disc pictured at left is an example of a combination insulating and conducting surface Metaplated in specific areas for control of precise electrical equipment.

Write or wire our Engineering Department concerning your problem.

Metaplast

**U.S. Patents 2,214,646-2,303,891 U.S. and Foreign Patents*

METAPLAST CORPORATION 205 WEST 19th STREET ★ NEW YORK 11, N. Y.

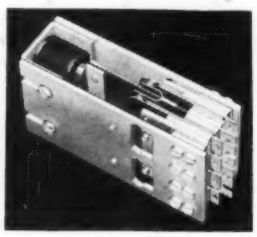
PAINTED FOR ELECTRONIC LABORATORIES, INC., BY BENTON CLARK

NOT HERE, Hirohito!

● **So sorry, son of heaven, but the answer is "NO! You can't land here!"** . . . Not with these gallant little sluggers, the PT boats, on the job. They're tough. They're fast. They never sleep. And whatever the occasion demands, they've got what it takes.

As a concentrated package of poison for the Axis, the PT boats are an outstanding example of the way American engineers, workers and management are teaming together to produce the deadliest weapons the world has ever known. And naturally, we're proud that ***E·L*** equipment is giving a good account of itself on PT boats.

The widespread use of ***E·L*** Vibrator Power Supplies as standard equipment—on land, sea and air—for radio, lighting, communications, etc.—wherever electric current must be changed in voltage, frequency or type—is evidence of the efficiency and rugged dependability of ***E·L*** products.



***E·L* Tandem Type Vibrator** — For changing DC to AC in Vibrator Power Supplies. Delivers as much as 750 watts DC or AC. Input Voltage: 4-220 volts; Input Wattage Rating (max.): 125-1000 watts, depending upon input voltage; Frequencies: 60, 100, 120 standard; 20-120 available range; effective life: 1500 hrs.

Electronic

LABORATORIES, INC.

INDIANAPOLIS

***E·L* ELECTRICAL PRODUCTS** — Vibrator Power Supplies for Communications . . . Lighting . . . Electric Motor Operation . . . Electric, Electronic and other Equipment . . . on Land, Sea or in the Air.

SPECIAL DELIVERY for 19 Hermannstrasse, Munich

RADIO COMPASS INDICATOR, ANOTHER BOES PRODUCT.

NEXT door delivery's no good . . . only a second-rate beer-hall there. But in just 95 seconds, Mr. Goering's Diesel factory at Number 19 will be going out of business for good. No mistake!

The stunning accuracy of American pin-point bombing holds out more than a promise that we'll inevitably smash the axis. Through it, we're proving a unique ability to weld men, ships and instruments into units of deadly accurate efficiency. Today these units dominate the world's military thought. Think what they'll do tomorrow . . . when the world's wide skyways beckon!

Make no mistake, the precision instruments are as fully important as the other components of these units. Boes builds electrical and navigational instruments that afford extreme precision and reliability . . . exact performance at any altitude, any attitude, any temperature. Tomorrow they'll be built for . . . who can tell? There will be new methods for new uses, certainly . . . but Boes will engineer and build them, too.

The W. W. **BOES** *Co., Dayton, Ohio.*

MANUFACTURERS OF ELECTRICAL AND NAVIGATIONAL INSTRUMENTS FOR AIRCRAFT

WAR STAMPS SPEED VICTORY • BONDS HELP EVEN MORE • HOW ABOUT AN EXTRA ONE TODAY?

Whenever Direct Current Is Required from an A. C. Source

Remember B-L Metallic Rectifiers!

BL
METALLIC RECTIFIERS

Copper Sulphide or *Selenium*

from Milliwatts to Kilowatts!

If you have an A.C.-D.C. conversion problem let our engineers help you. We have successfully produced many applications formerly thought impractical.

B-L Metallic Rectifiers have been favorably known to the electrical industry for many years for their reliability and efficiency.

We invite the submission of your A.C.-D.C. conversion problems. We are equipped to render a thorough engineering service—at no obligation.

Write today for Bulletin 72 giving full details about B-L Metallic Rectifiers.

BL

THE BENWOOD LINZE COMPANY • ST. LOUIS, MO.

Designers and manufacturers of Copper Sulphide and Selenium Rectifiers, Battery Chargers, and D.C. Power Supplies for practically every requirement

MASTER ENGINEERING TAKES NOTHING FOR GRANTED

Properly engineered mass production can provide equipment of as high a stage of precision as it is possible to produce. In fact some of today's mass production is infinitely better than the hand made originals.

The products of Techrad are mass produced and they are backed by a high order of engineering. Thus Techrad is able to provide radio equipment in volume . . . which is of the highest quality . . . everything from small parts to complete transmitters. For this reason Techrad products are much in demand for exacting wartime jobs today. Tomorrow Techrad will again devote its resources and skill to the advancement of radio communications in all the peacetime applications as it has done for 10 years.

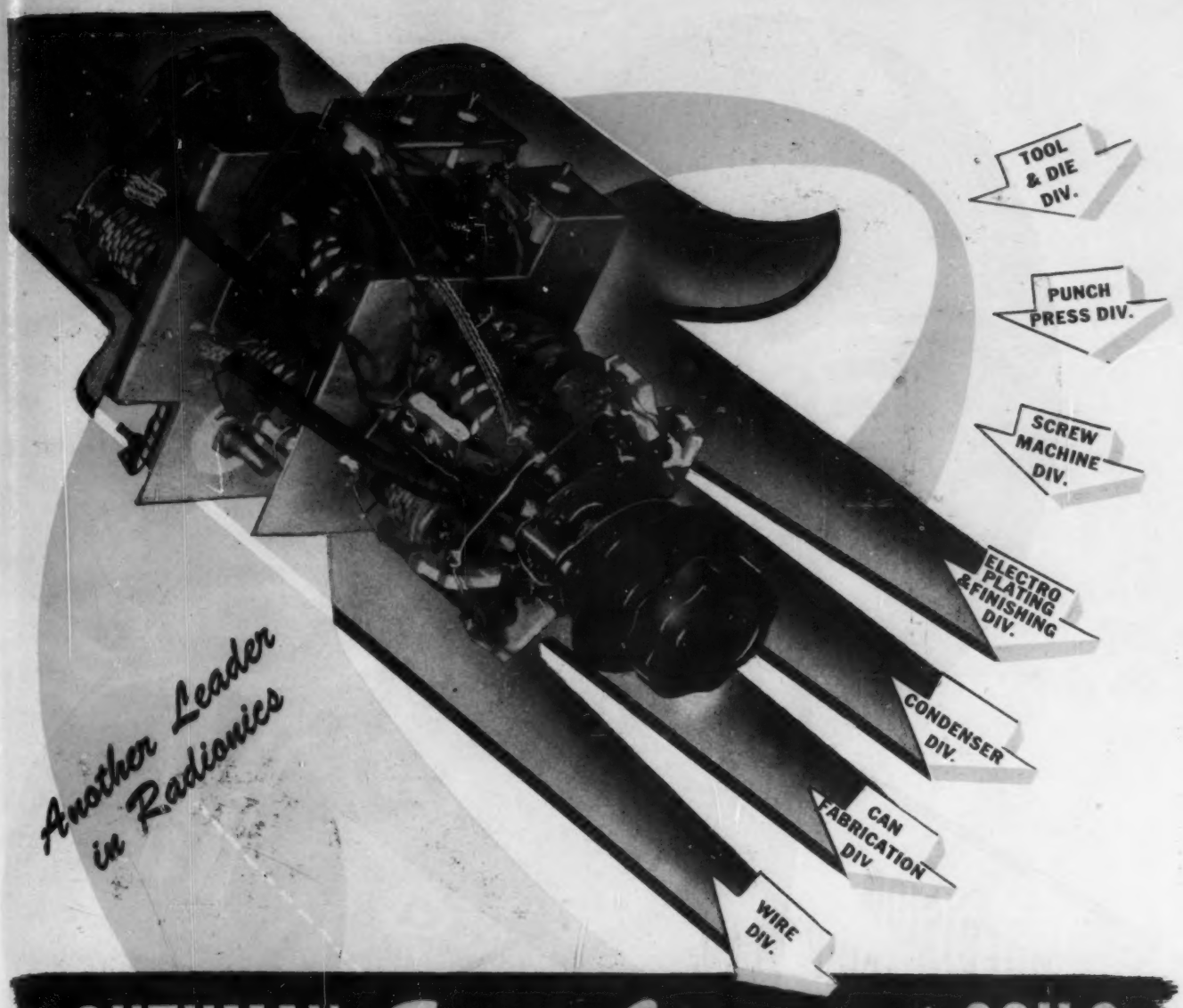
Remember the name Techrad . . . and remember too that Techrad stands for sound engineering first and mass production second . . . the one assuring near perfection in the other.

TECHRAD PRODUCTS

Over 10 years Continuous Experience

Technical Radio Company, 275 Ninth Street, San Francisco, California

Export Agents: FRAZAR & HANSEN, 301 Clay Street, San Francisco, California, U. S. A.



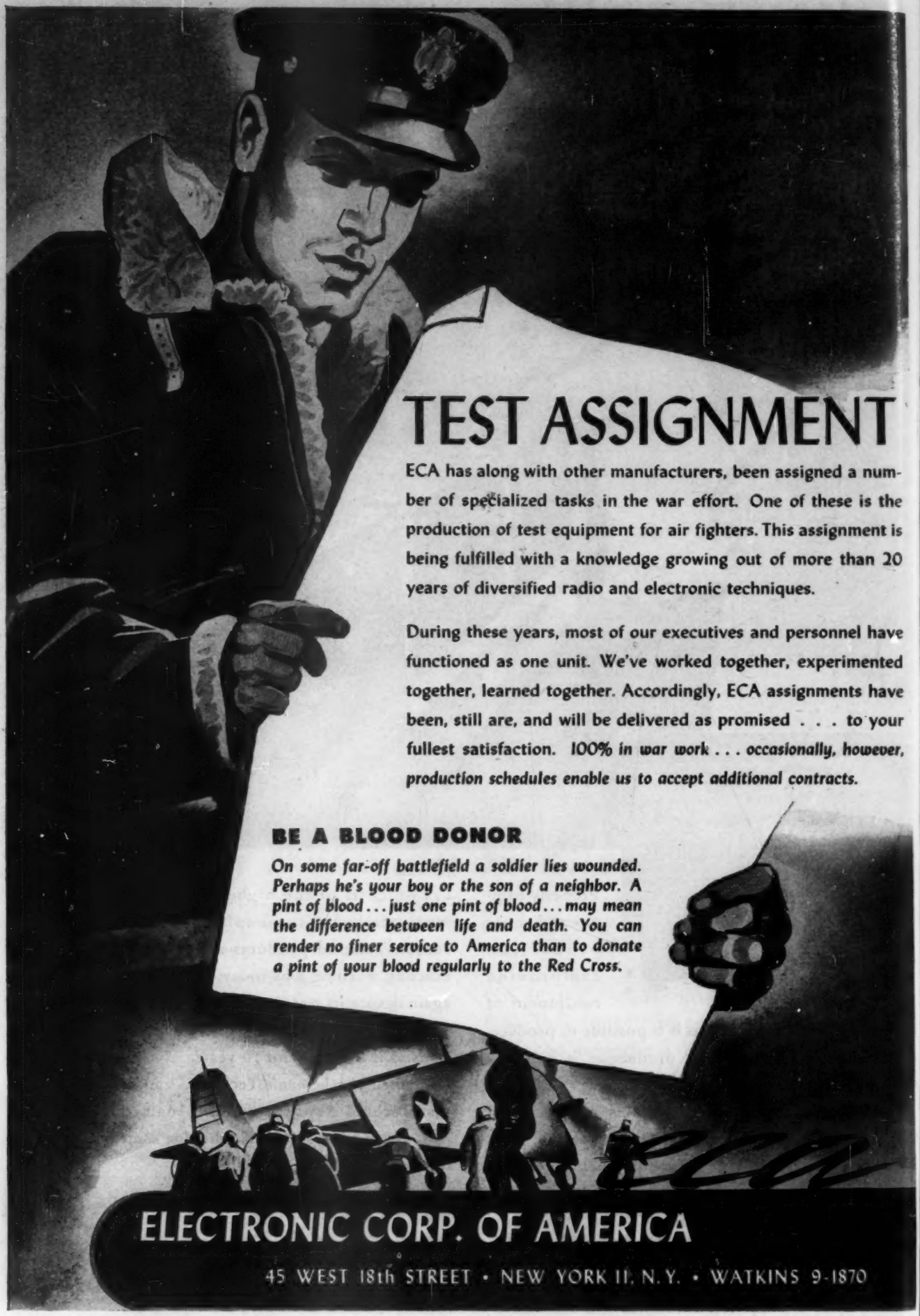
GUTHMAN *Super-Improved* COILS

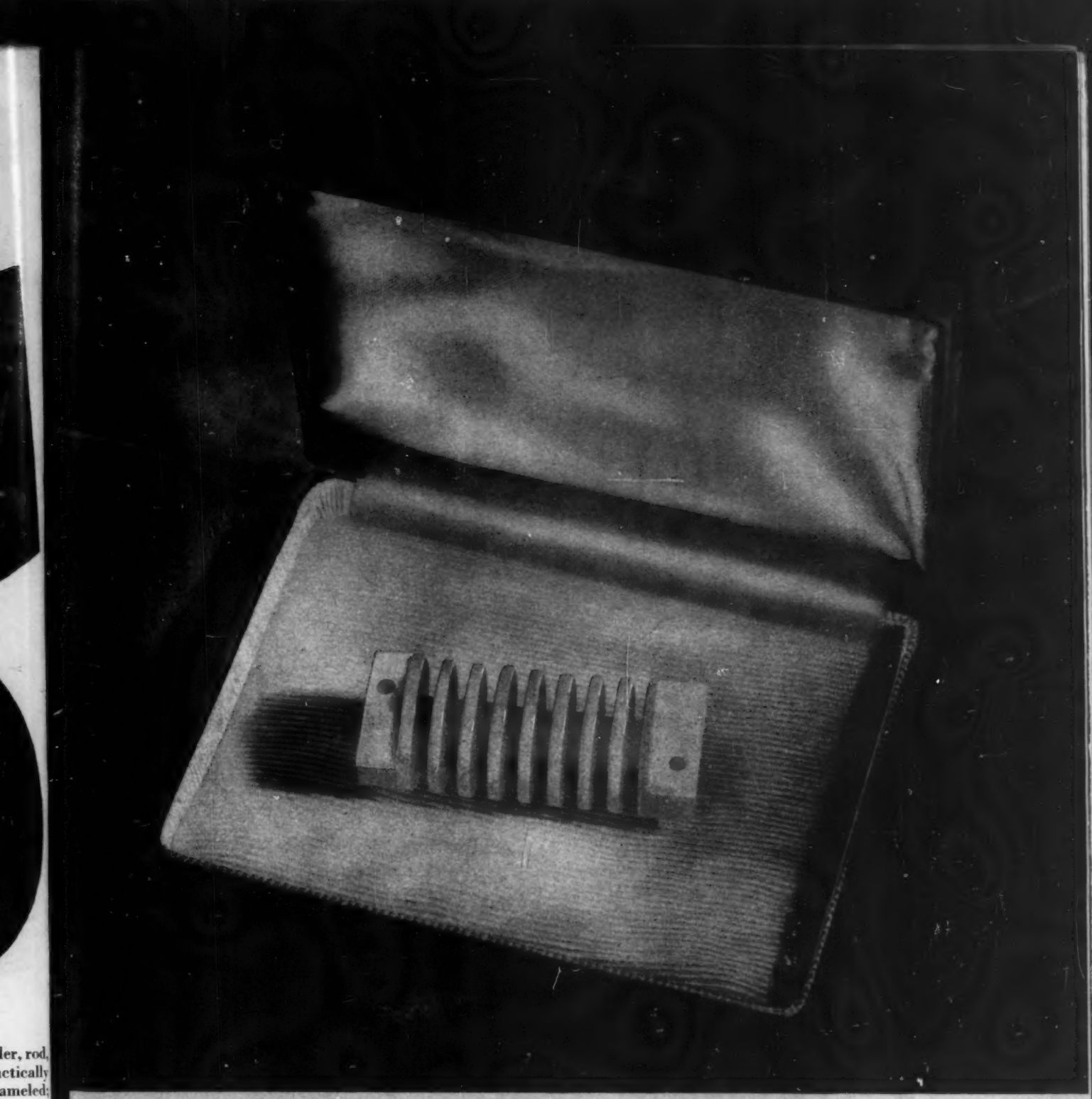
For many years before the war, Edwin I. Guthman & Co. was especially known for manufacturing better coils. With war came greater demands upon our facilities... U. S. Army and Navy orders for many diversified radio parts... expansion of our plant... the addition of many new manufacturing departments. All manufacturing and assembling of these many units was done in our own completely equipped plant. Thus, our engineers and skilled personnel gained a broader experience in modern radionics. Now, we are concentrating all this technical experience in the engineering and production of Guthman Super-Improved Coils... promised leaders in peacetime radionics.

EDWIN I. GUTHMAN & CO. INC.

15 SOUTH THROOP STREET · CHICAGO

PRECISION MANUFACTURERS AND ENGINEERS OF RADIO AND ELECTRICAL EQUIPMENT


TEST ASSIGNMENT
ECA has along with other manufacturers, been assigned a number of specialized tasks in the war effort. One of these is the production of test equipment for air fighters. This assignment is being fulfilled with a knowledge growing out of more than 20 years of diversified radio and electronic techniques.
During these years, most of our executives and personnel have functioned as one unit. We've worked together, experimented together, learned together. Accordingly, ECA assignments have been, still are, and will be delivered as promised . . . to your fullest satisfaction. 100% in war work . . . occasionally, however, production schedules enable us to accept additional contracts.
BE A BLOOD DONOR
On some far-off battlefield a soldier lies wounded. Perhaps he's your boy or the son of a neighbor. A pint of blood . . . just one pint of blood . . . may mean the difference between life and death. You can render no finer service to America than to donate a pint of your blood regularly to the Red Cross.
ELECTRONIC CORP. OF AMERICA
45 WEST 18th STREET • NEW YORK 11, N.Y. • WATKINS 9-1870



THE IMPERISHABLE QUALITY OF A GEM

PRIDE of craftsmanship which produced the exquisite steatite cameos and intaglios of the ancient Greeks and Romans lives today in the fine workmanship, characteristic of ALSIMAG Steatite Ceramic insulators for electronic uses.

And the imperishable qualities of those ancient steatite gems that have survived thousands of years are present in greater measure in ALSIMAG Steatite Ceramics.

Permanent in their hardness, strength and rigidity . . . impervious to heat up to 1000°C . . . insulating qualities unimpaired even with arc-overs . . . impervious to moisture . . . ALSIMAG Steatite Ceramics perform in a manner impossible of perishable organic materials.

. . . .

ALSIMAG is produced in a variety of bodies with electrical properties to fit your requirements. Our Research and Engineering staff will gladly cooperate in designing Steatite Ceramic insulation for economy in production.

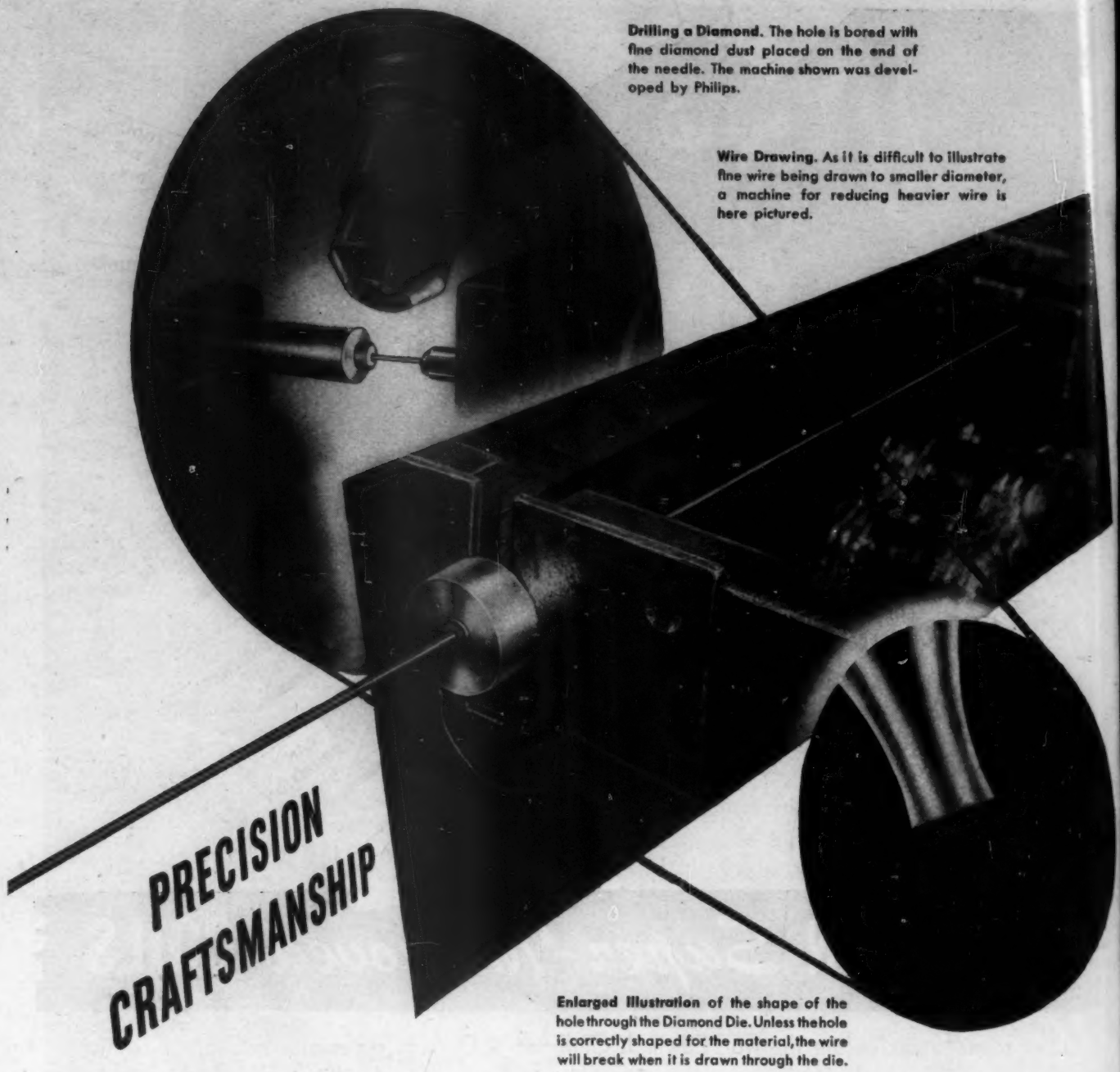
ALSIMAG

TRADE MARK REGISTERED U. S. PATENT OFFICE

STEATITE CERAMIC ELECTRICAL INSULATION
FOR ELECTRONIC USES

AMERICAN LAVA CORPORATION

CHATTANOOGA 5 TENNESSEE



Drilling a Diamond. The hole is bored with fine diamond dust placed on the end of the needle. The machine shown was developed by Philips.

Wire Drawing. As it is difficult to illustrate fine wire being drawn to smaller diameter, a machine for reducing heavier wire is here pictured.

PRECISION CRAFTSMANSHIP

Enlarged Illustration of the shape of the hole through the Diamond Die. Unless the hole is correctly shaped for the material, the wire will break when it is drawn through the die.

Precision manufacture by North American Philips is exemplified in the Diamond Die and Wire Drawing Divisions. Machines both for making diamond dies down to .0005 of an inch and drawing wire to that diameter are Philips developments.

The tiny hole drilled through the diamond to make the die not only must be exactly the diameter specified, but it must have a smooth, cone-shaped opening, as illustrated. The operation may take weeks. The drilling is under constant inspection for accuracy through a powerful microscope.

This example of precision craftsmanship is but one of many in the wide background of research and development of our engineers.

Today this knowledge is being used to hasten Victory; tomorrow it will be available to aid Industry.

For our Armed Forces we make Quartz Oscillator Plates; Amplifier, Transmitting, Rectifier and Cathode Ray Tubes for land, sea and air-borne communications equipment.

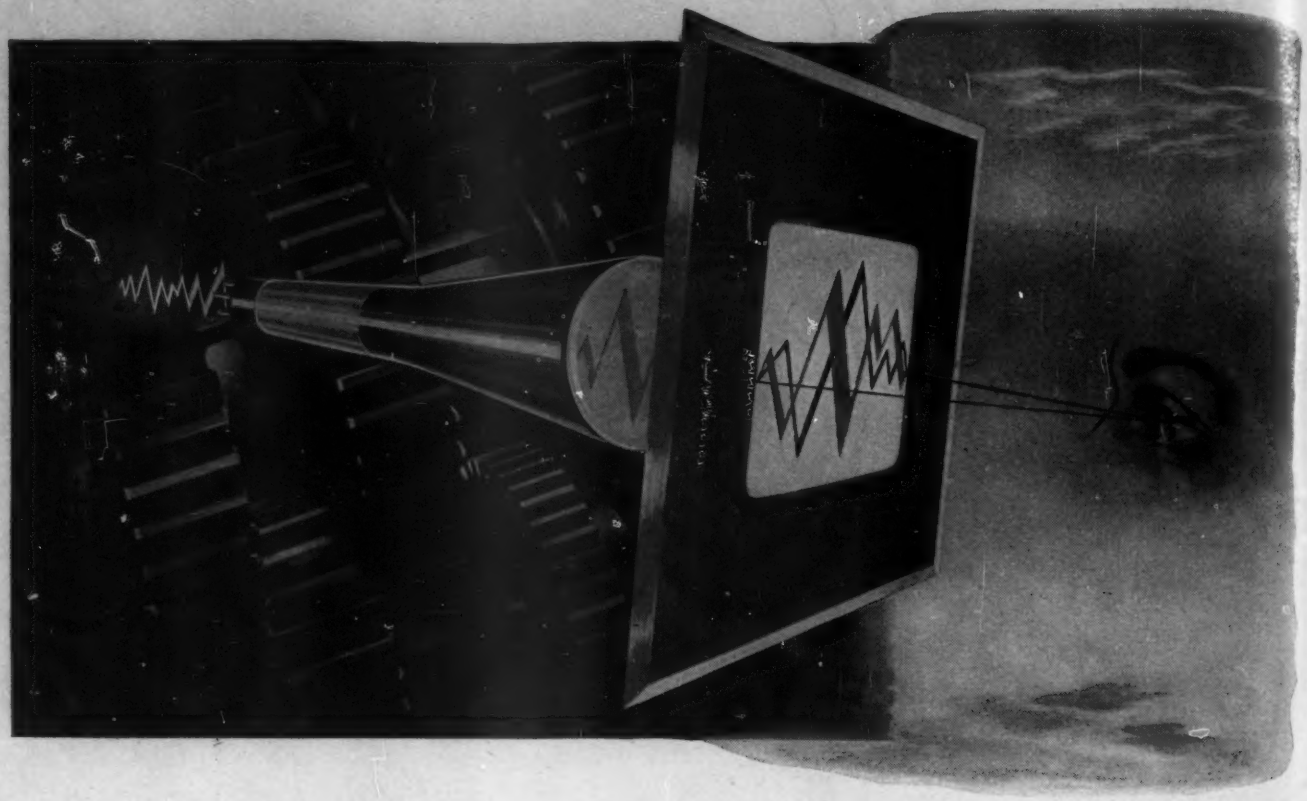
For our war industries we make Searchray (X-Ray) apparatus for industrial and research applications; X-Ray Diffraction Apparatus; Electronic Temperature Indicators; Direct Reading Frequency Meters; Tungsten and Molybdenum in powder, rod, wire and sheet form; Tungsten Alloys; Fine Wire of practically all drawable metals and alloys: bare, plated and enameled; Diamond Dies; High Frequency Heating Equipment.

And for Victory we say: Buy More War Bonds.

Norelco

ELECTRONIC PRODUCTS by
NORTH AMERICAN PHILIPS COMPANY, INC.
Executive Offices: 100 East 42nd Street
New York 17, New York

Main factory in Dobbs Ferry, New York; other factories at Lewiston, Maine (Elmet Division); Mount Vernon, N. Y. (Philips Metalix Corp.)



Key to a world within a world

To inspect metal, judge its inner worth with the aid of electronics, is to add a vital chapter to war industry's book of knowledge. More, it is to write a preface to the mightier book of the future.

This same science of electronics, which finds the structural flaw in war metal, holds great possibilities whose commercial use awaits only the welcome day of peace.

Infinite additions to the knowledge, the safety, the comfort of modern man continuously reveal themselves in the quick flutter of the electronic tubes.

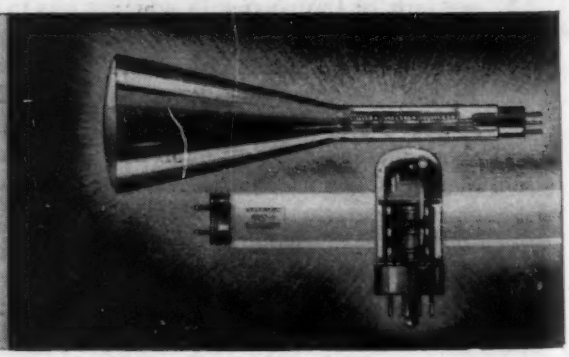
This is an inspiring reason why at Sylvania, in our work with electronics, as in everything else we do to widen the range of the eye and the ear, we set for ourselves a single goal — the highest standard known.

SYLVANIA ELECTRIC PRODUCTS INC. formerly Hygrade Sylvania Corporation

EXECUTIVE OFFICES: 500 FIFTH AVENUE, NEW YORK 18, N. Y.

RADIO TUBES, CATHODE RAY TUBES, ELECTRONIC DEVICES, INCANDESCENT LAMPS, FLUORESCENT LAMPS, FIXTURES AND ACCESSORIES

AIDING THE HOME FRONTS "KNOW-HOW"—Sylvania Fluorescent Lamps and Fixtures give war workers the light they need to produce their armament miracles. Sylvania Radio Tubes bring the news of the world to the American family, keep our people mentally alert. Sylvania Incandescent Lamps economically protect the eyes of the American family. Indeed, the Sylvania name now, as always, means the ultimate in product performance.



FOR *Outstanding Production* OF VARIABLE AIR CONDENSERS

Radio Condenser Company has been awarded the coveted Army-Navy "E".

Of this award we are proud.

It means we are succeeding in our efforts to supply our armed forces with quality, and quantity, variable air condensers.

Today these condensers are being used exclusively by the branches of our armed forces—land, sea, air.

Tomorrow, they will be available to all manufacturers of radio sets.

In planning your post-war radio manufacture, plan to use Radio Condenser Company products: variable air condensers and push button tuning devices.

RADIO CONDENSER CO.

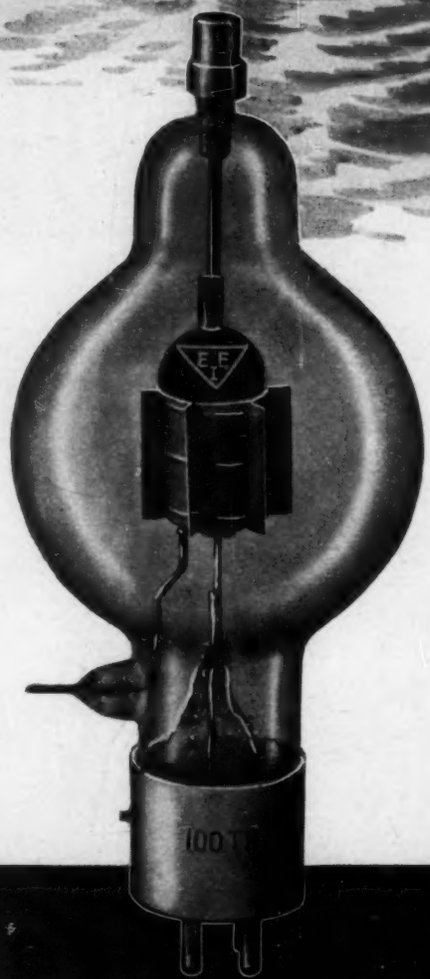
CAMDEN, N. J.

RADIO CONDENSER CO. LTD., TORONTO, CAN.

One of the first requisites of military strategy is secrecy, with the odds favoring the surprise element. Whereabouts of an Armada can hardly be kept unknown to a cautious and intelligent adversary, when continuous radio intercommunication "beams" the task force . . . and presents the foes with an excellent radio "fix".

One of the simpler methods utilized, is to transmit key commands from a source outside the battle area to the attacking vessels. These, in turn, blast fourth the orders from bridge to deck to auxiliary ships, through the medium of electronic voice amplification. Thus the blacking out of radio and blinker signals has advanced a new technique—the limited range of which assures the desired secrecy.

Electronic tubes are vital components in this phase of the war effort, just as they are in every other branch of the Armed Forces. Their multitudinous uses in war will only be surpassed by the tremendous peace-time incorporations now in process. Inquiries are invited.



ELECTRONIC ENTERPRISES, INC.

ELECTRONIC e ENTERPRISES

65-67 SEVENTH AVENUE, NEWARK, 4, NEW JERSEY

EXPORT DEPT. 25 WARREN STREET, NEW YORK CITY, N. Y. CABLE ADDRESS: SIMONTRICE, N. Y.

LOOKING *into the Future* NOW

If the history of metals in this war is ever written in full, the contribution of laboratory technicians will be revealed.

Most of the alloys now in use were first melted in a small AJAX-NORTHRUP furnace. The fast melts, perfect control, ability to vary or duplicate and the comfortable working conditions are known to most of the university and industrial metallurgical laboratories in the country.

But as these men now work to solve war problems they get glimpses of the future too. The tremendous increase in the use of high frequency for testing, pilot plants, large scale melting, heating and brazing, are like handwriting on the wall.

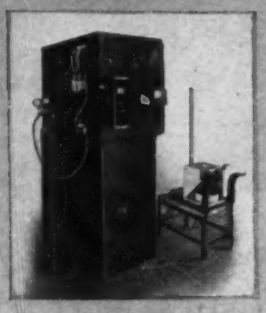
They see the vision of duplicating laboratory discoveries in future quantity peace time production with a certainty as to results, timing and cost.

Only a few of the smaller AJAX-NORTHRUP furnaces are shown on this page.

AJAX furnaces range from 1 oz. to 8 tons and from 60 to 1,000,000 cycles. Oscillators, tube converters, and motor generators provide the power. AJAX also provides the experience that has successfully solved hundreds of unusual problems from brazing fuse-seat liners to hardening razor blades or melting special alloys at the rate of 44 tons in 24 hours.

Catalogs on heating, melting, or laboratory units will be sent on request. Inquiries from manufacturers desiring to incorporate electronic heating in their post-war products are particularly welcome.

3 to 6 Kw.
Converter with 3P4 Furnace and Truck



20 to 40 Kw.
Converter with 17 pound Furnace

15 to 60 Kw.
Tube Converter

AJAX HIGH FREQUENCY FURNACES

NORTHRUP AJAX ELECTROTHERMIC CORPORATION, AJAX PARK, TRENTON, N.J.

ASSOCIATE COMPANIES: THE AJAX METAL CO. *Non-Ferrous Ingot Metal for foundry use.*
AJAX ELECTRIC FURNACE CORPORATION. *Ajax-Wyatt Induction Furnaces for melting.*
AJAX ELECTRIC CO., INC. *Ajax-Hultgren Salt Bath Furnace and Resistance Type Electric Furnaces.*
AJAX ENGINEERING CORPORATION. *Aluminum Melting Furnaces.*

RANGES

D-C Voltage—*Measurements from 10 millivolts to 1000 volts (20,000 ohms per volt) in full scale ranges of: 1/10/50/200/500/1000 volts. (Up to 5000 volts with very compact external multiplier.)*

A-C Voltage—*Measurements from 0.1 to 750 volts (1000 ohms per volt) in full scale ranges of: 5/15/30/150/300/750 volts.*

D-C Current—*Measurements from 0.5 microampere to 10 amperes, in full scale ranges of: 50 microamperes, 1/10/100 milliamperes, 1/10 amperes. (Higher ranges with external shunts.)*

A-C Current—*Measurements from 10 milliamperes to 10 amperes, in full scale ranges of: .5/1/5/10 amperes. Higher ranges, up to 1000 amperes, with external current transformers.*

Resistance—*Measurements from 0.5 ohm to 30 megohms in full scale ranges of: 3,000/30,000/300,000/3 meg./30 meg. Center scale values are: 25/250/2,500/25,000/250,000 ohms.*

• The growing use of electronic devices and other sensitive circuits throughout industry poses no new instrument problems for contractors or maintenance departments WESTON equipped. The familiar Model 785, with its high sensitivity and broad range scope, answers these newer measurement requirements. But more . . . it also covers most of the usual maintenance needs.

Model 785 furnishes another example of WESTON'S engineering foresight . . . designing instruments always with the needs of to-morrow in mind. Other WESTONS, equally important for efficient maintenance in the days to come, are the time-saving WESTON Clamp Ammeter, and the WESTON foot candle meters which measure all types of lighting direct . . . *without correction factors.* Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark 5, New Jersey.

Laboratory Standards . . . Precision DC and AC Portables . . . Instrument Transfomers . . . Sensitive Relays . . . DC, AC, and Thermo Switchboard and Panel Instruments.

WESTON

Specialized Test Equipment . . . Light Measurement and Control Devices . . . Exposure Meters...Aircraft Instruments... Electric Tachometers...Dial Thermometers.

FOR OVER 55 YEARS LEADERS IN ELECTRICAL MEASURING INSTRUMENTS

To All Our Friends in The Electronics Field Lots of Good Wishes for Christmas

. . . and this
happy holiday reminder that
we also have

LOTS OF* MYKROY

For today's more critical standards in high frequency insulation, there is nothing more practicably perfect than MYKROY. . . . MYKROY is the last word in low-loss dielectrics. It is glass-bonded mica in its most advanced form. . . . MYKROY molds readily and bonds well with metals. It can be machined to close tolerances . . . is virtually impervious to moisture. . . . There is no longer any shortage of MYKROY. With greatly increased facilities, our Clifton plant can fill orders for any amount of stock (sheets and rods) or manufacture component parts to your specifications. Ample stocks are available at our Chicago plant.

Write for detailed information. Bring us your insulating problems.

*MYKROY has such good structural qualities that it can be formed into a wide range of shapes, such as these block letters.

EXCLUSIVE MANUFACTURERS

ELECTRONIC MECHANICS INC.

70 CLIFTON BOULEVARD
CLIFTON, NEW JERSEY

Chicago 47
1917 No. Springfield Ave.—Tel. Albany 4310

Export Department
85 Broad Street, New York 4, N. Y.

at this demonstration of Farnsworth Television

Near where Ben Franklin revealed his electrical discoveries, other American scientists in 1934* first demonstrated to the public a new modern-day wonder . . . *electronic television.*

Using equipment developed and built by Farnsworth engineers, the showing drew crowds to Philadelphia's famed Franklin Institute to see a practical exhibition of electronic television.

Today, the original Farnsworth Dissector Tube, cathode ray tubes, synchronizing devices and circuits have been brought to high perfection. Parallel research in both tubes and circuits has produced important developments in Farnsworth transmitting and receiving equipment.

Hastening the day of country-wide television are Farnsworth's 100% war production, Farnsworth consumer advertising, and Farnsworth research (which has continued uninterruptedly for 18 years). After the war, which has slowed television's public growth, but advanced its technical development, we'll be well equipped to help and serve you.

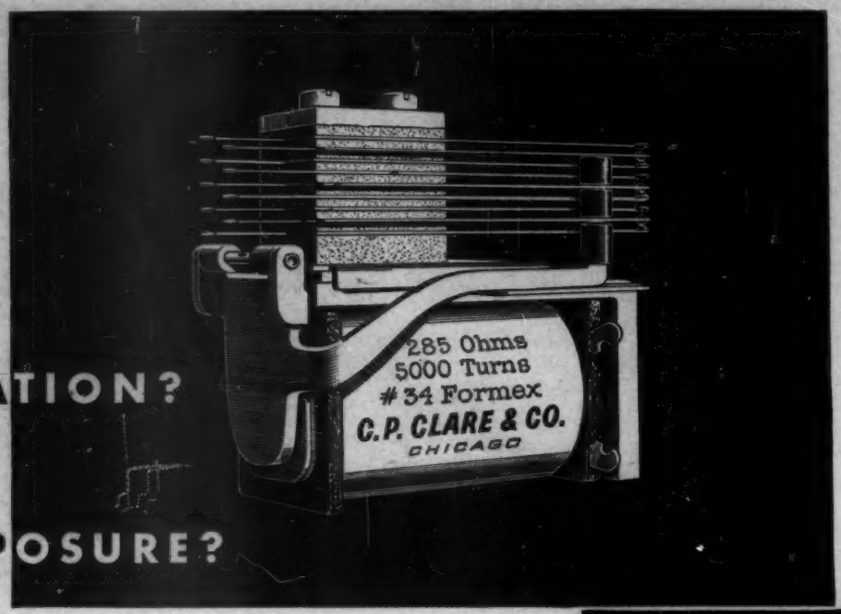
**Another in a series of advertisements depicting milestones in the history of television.*

LOOK FOR the Farnsworth Television advertisement in: November 15 *Newsweek* and November 27 *Collier's*.

FARNSWORTH TELEVISION

ARMY E NAVY

• Farnsworth Television & Radio Corporation, Fort Wayne 1, Indiana. Farnsworth Radio and Television Transmitters and Receivers; Aircraft Radio Equipment; the Farnsworth Dissector Tube; the Capehart, the Capehart-Panamuse; the Farnsworth Phonograph-Radio.



VIBRATION?

SHOCK?

EXPOSURE?

This CLARE Type G Relay Withstands Them All!

THIS Clare Type G Relay has come through the rigorous tests of war with flying colors. Its ability to withstand unusual shock, vibration and exposure has been proven time and time again in aircraft use, in radio equipment, compasses and controls of all kinds.

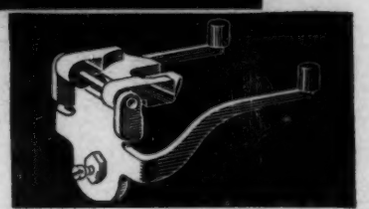
Clare Type G is a short coil relay—just 2½" x 2¼" x 1¼" and weighs but 6½ ounces. Coils are carefully wound to exact turns on precision machines. They are protected with a transparent acetate covering and are available impregnated with special varnish. The pile-up shown is of nine springs, but as many as twelve springs can be used.

Permanency of the spring tension is assured by the way in which the spring pile-up is assembled. Heelpiece and pile-up are placed in a hydraulic press while automatic screw drivers tighten the high tensile screws which hold the pile-up to the heelpiece.

Contacts of rare metals or special alloys can be used either flat or hemispherical and in sizes from .062" to .1875" diameter. The core, heelpiece and armature are made from the highest quality magnetic iron. This is purchased to rigid specifications and carefully annealed in precision controlled furnaces in our own factory.

Type G like all Clare "custom built" relays can be accurately adapted to the specific requirements of your design. We will be glad to work with you to that end. Let us know what your relay problem is. Our engineers will be glad to put our years of relay experience at your service.

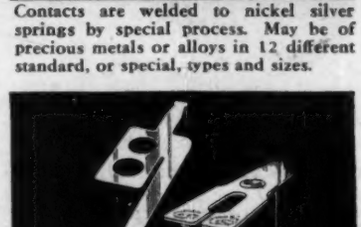
Send for the Clare catalog and data book. C. P. Clare & Company, 4719 West Sunnyside Ave., Chicago (30), Ill. Sales engineers in all principal cities. Cable address: CLARELAY.



Double arm armature assembly of stainless steel shaft, operating in a marine brass yoke. Heelpiece, core and armature assembly of magnetic metal.

High voltage spring pile-up insulators of special heat treated Bakelite. Has minimum cold flow properties, low moisture absorption content; and permits punching without cracks or checks.

Contacts are welded to nickel silver springs by special process. May be of precious metals or alloys in 12 different standard, or special, types and sizes.



Spring bushing insulators are made of Bakelite rod under patented process. Resist vibration and withstand heavy duty service.

CLARE RELAYS

"Custom-Built" Multiple Contact Relays for Electrical, Electronic and Industrial Use

the amateur is still in radio...

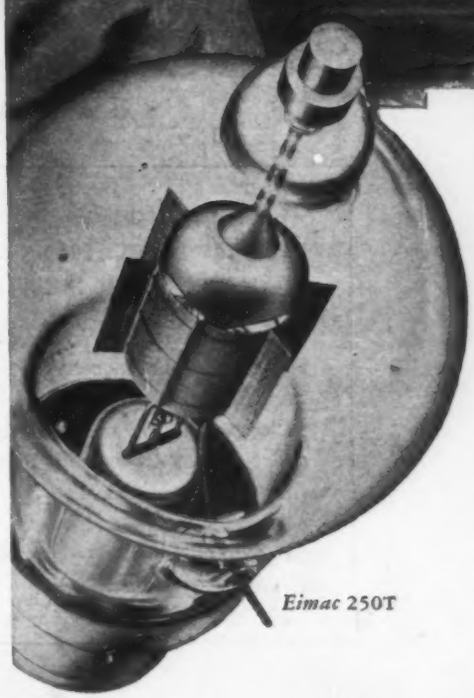
All through the development of radio communications you'll find the mark of the radio amateur. His desire to accomplish the seemingly impossible and the rough treatment he gave his "ham rig" helped create and develop better radio technique. Thus the radio amateur is directly responsible for much of the superior radio and electronic equipment being used by the military services today. Eimac tubes, created and developed in the great amateur testing ground are a good example. They had to possess superior performance capabilities in order to become first choice of the leading radio amateurs.

Their ability to withstand mc mentary overloads of as much as 600% and their unconditional guarantee against premature failures due to gas released internally are two potent reasons why they are today first choice of the leading electronic engineers throughout the world.

Follow the leaders to

Today the radio amateur is off the air as an amateur but he's still in radio as a professional. And wherever he is... in the army, navy and marine corps... in the great electronic laboratories and factories .. he's still using Eimac tubes.

Eimac REG. U. S. PAT. OFF. TUBES



Eimac 250T

EITEL-McCULLOUGH, Inc., SAN BRUNO, CALIF.

Plants at: Salt Lake City, Utah and San Bruno, California

Export Agents: FRAZAR & HANSEN, 301 Clay Street, San Francisco, California, U. S. A.

NEED A QUICK DEPENDABLE SOURCE FOR SPECIFICATION PARTS IN

PHENOL FIBRE OR VULCANIZED FIBRE?

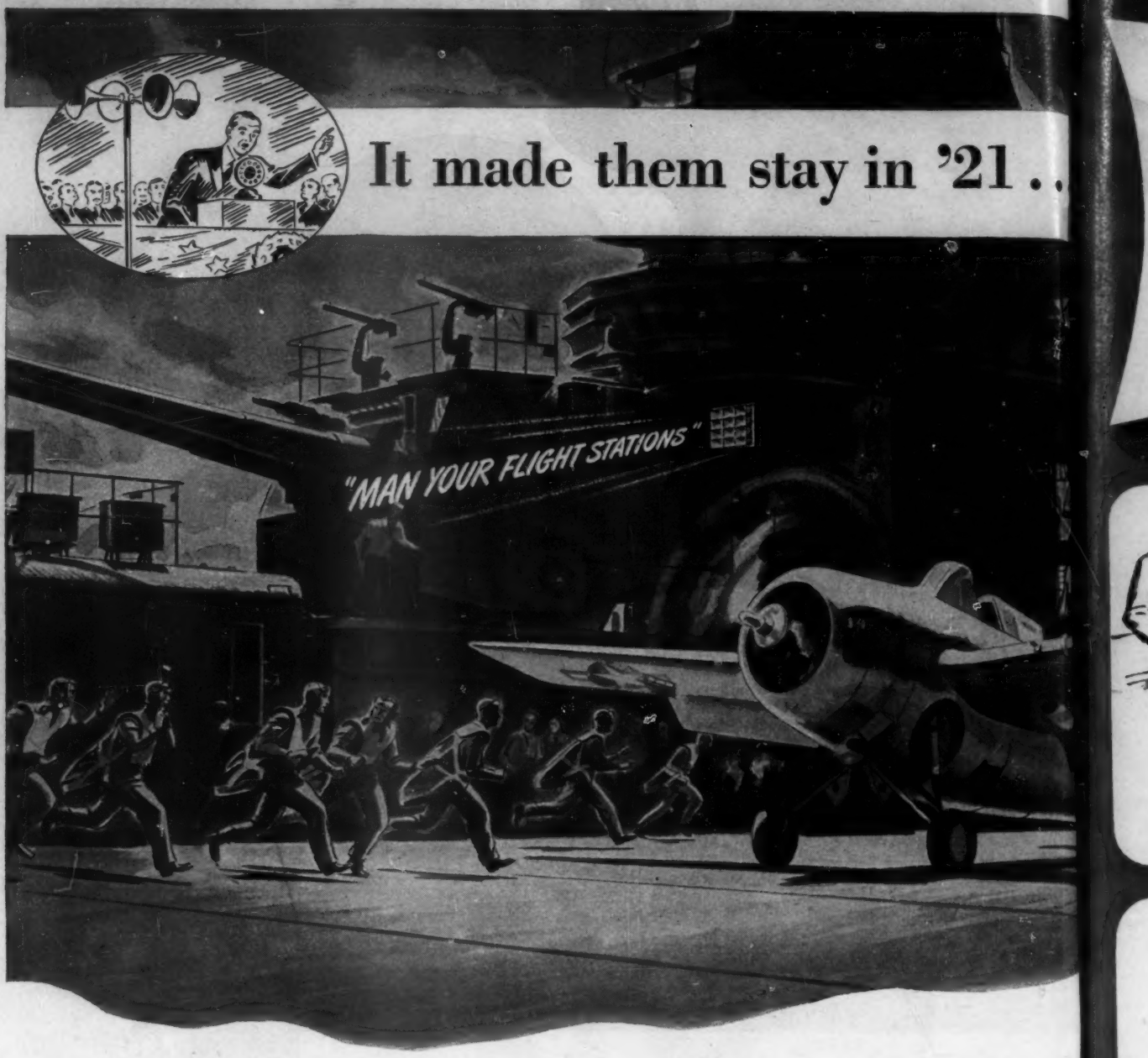
The experience of producers of hundreds of electrical and electronic devices can be summed up quickly: *"On parts from phenol fibre and vulcanized fibre, Precision Fabricators meet specified tolerances, and meet specified delivery dates."*

Precision Fabricators, Inc., solicits the opportunity of looking over your blueprints. We think we can save you money and save you time on vulcanized fibre, phenol fibre and glass-bonded mica parts cut, milled, drilled, threaded, grooved, turned, surfaced, polished or engraved

PRECISION Fabricators INC.

ROCHESTER N.Y.

SPECIFICATION FABRICATORS OF MYCALEX ★ PHENOL FIBRE ★ VULCANIZED FIBRE ★ RUBBER ★ ASBESTOS AND OTHER MATERIALS



It made them stay in '21 . .

. . . it tells 'em to scram today!

PEACETIME SOUND-TRANSMISSION PRODUCTS BY WESTERN ELECTRIC INCLUDE:

Bell Telephones, switchboards and cables—broadcasting apparatus—aviation, marine and police radio telephones—public address systems—sound picture equipment—aids for the hard of hearing—audiometers for testing hearing — sound measuring equipment.

On March 4, 1921, over 100,000 persons assembled in the Capitol Plaza at Washington clearly heard President Harding's inaugural address — thanks to Western Electric public address equipment.

Today, Western Electric battle announcing equipment delivers commands instantly on aircraft carriers and flying fields—saves precious seconds in getting planes into the air.

Our work on many kinds of mil tary communications equipment adding steadily to the specializ knowledge which has made Weste Electric the leader in sound-tran mission apparatus. Tomorrow, th new knowledge will be applied peacetime products.

★

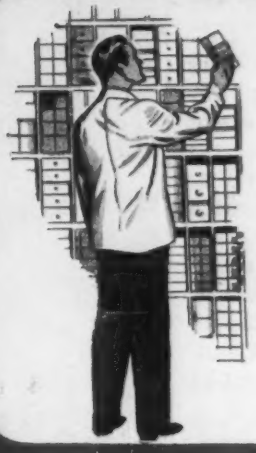
Buy War Bonds regularly—all you c —from now till Victory!

Western Electric
ARSENAL OF COMMUNICATIONS EQUIPMENT

4 WARTIME SERVICES YOUR LOCAL RCA TUBE DISTRIBUTOR OFFERS YOU TODAY

1. Technical "Know how"

He started in Electronics on the ground floor . . . with *radio.* His advice and recommendations about circuits, tubes, and other electronic components are valuable to you.



2. Supply of Stocks

He's right around the corner; check with him first for items you need to fill on a rush priority basis.

3. Fast Delivery

If his normally adequate and varied stock should *not* include what you want, he's your one best bet today for locating it *fast!*

4. Intelligent Expediting

He's an old hand at tackling tough jobs. That's his business.
When you're in a jam, you'll find him well qualified to act as your expediting specialist.

Get to know this man. He's eager to help you. He's your EMERGENCY ELECTRONIC EXPEDITER! If you don't know where to find him, write us for the list showing your nearest RCA Tube & Equipment Distributor. RCA Victor Division, RADIO CORPORATION OF AMERICA, Camden, N. J.

TUNE IN "WHAT'S NEW?" RCA's great new show, Saturday nights, 7 to 8, E. W. T., Blue Network.

The Magic Brain of All Electronic Equipment is a Tube and the Fountain-Head of Modern Tube Development is RCA.

BUY WAR BONDS

RCA

RCA ELECTRON TUBES

ASK ABOUT... RCA INDUSTRIAL MUSIC SERVICE

The purity meter for testing distilled water and the glass dip conductivity cell, products of the Barnstead Still & Sterilizer Co., Inc. of Boston

and would close if the bridge were thrown off balance in the other. The frequency doubling arrangement eliminates this difficulty and at the same time retains the inherent simplicity of a completely a-c operated instrument.

The conductivity scale of the meter is calibrated from 0 to 15 parts per million and can be read to 0.25 ppm in the range from 0 to 5. The temperature correction scale has a range from 64 to 190 deg. F.

• • •

HELMET FOR ANTENNA

Adjusting a "Raider" radio receiver used by paratroopers and raiders to receive orders in action. The helmet acts as the antenna and also contains fabric cups that enclose the earphones. The receiver, a development of Emerson Radio & Phonograph Corp., is mounted with its battery in the chest pack

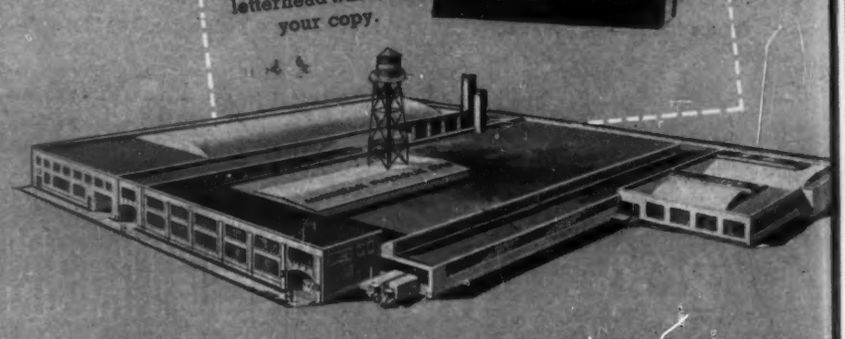
Building

• Building today in unlimited quantities the vital electrical and high frequency equipment for practically every phase of the war effort, Amphenol, with this experience is also anticipating the great future of the electronics industry.

New and unusual types of connectors—new and more efficient wiring systems for high frequency currents—new and improved applications for polystyrene and other plastic insulations—these and many other products of Amphenol research will set new standards of performance, economy, and service in postwar industry.

Now, for electrical war equipment—later, for peacetime applications—you can depend upon Amphenol quality.

The Amphenol Catalog and Handbook lists and describes Amphenol A-N Connectors, High-Frequency Coax and Twinax Cables, and other Radio and Electrical Products. A request on your letterhead will bring your copy.



AMERICAN PHENOLIC

WANTED

SENIOR ENGINEER

with at least seven years industrial experience in important electronic research and development work. Capable of executing important assignments from development to finished products.

JUNIOR ENGINEERS

with sound educational background and at least one year's experience in factory or engineering departments.

These positions offer unusually good permanent opportunities—top compensation commensurate with qualifications—congenial, progressive organization with new and one of the best equipped laboratory and factory facilities in the industry. Interesting work on most advanced type of military communication equipment now and broad field of quality radio-phonograph and industrial electronics after V-Day. Please write detailed qualifications, including availability, if not occupied to full extent of ability in war work, to—

THE MAGNAVOX COMPANY
FORT WAYNE, INDIANA

WANTED

ENGINEERING TALENT

For Outstanding Opportunities

A well-organized, amply-financed manufacturing corporation located in Eastern Massachusetts has a number of permanent engineering positions affording excellent opportunities for top-notch engineers. To the right men, we are prepared to offer an almost unlimited future. Salary is good, and depends entirely on the individual and his experience. Here's what we want...

MECHANICAL AND ELECTRICAL DEVELOPMENT ENGINEERS

Three or four men experienced in development and engineering of electrical apparatus. They'll work in our engineering and development laboratory, and will have pretty much of a free hand in their work. Projects connected with the War effort will have first consideration, but when these are completed an extensive program of developments for commercial applications will be carried on continuously.

These jobs are not temporary, but definitely permanent positions. Engineers, with an eye to the future, may find one of these positions just what they're looking for.

Please give a full resume of education, experience, and date available. All replies will be held strictly confidential.

P-577, Electronics
330 W. 42nd St., New York 18, N. Y.

An Exceptionally

Attractive Opening

for an

Electronic Engineer

A Central Ohio manufacturer, now doing 100% war production in their regular line and a leader in their field, has a permanent position, affording excellent opportunity, for a practical, experienced electronic engineer with a general knowledge of manufacturing operations and an interest in the broad aspect of product development. Though not imperative, sufficient experience for seasoned judgment and analytical, market-wise keenness is preferred. Should be exempt if of draft age. Send photograph and outline qualifications fully in first letter. Also give some indication of salary expected. Application held in strict confidence.

P-581, Electronics
520 N. Michigan Ave., Chicago 11, Ill.

WE ARE LOOKING FOR A FEW MEN

There *are* only a few of the sort we want. They're engineers . . . men with a solid, expert background in electronic design . . . men who aren't hidebound in their thinking.

We offer them an unlimited *future* in a new scientific industry now working at full capacity on military devices. We want their expert talents to help us explore even further the peacetime possibilities of this new science.

It's a big job. It needs big men. If you think we're talking to you, write us your *whole* story and enclose a photo. Please don't phone or call until an appointment has been set up for you.

Chairman, Opti-onics Development

BELL & HOWELL CO.
7105 McCormick Road
Chicago 45, Illinois

POST-WAR ENGINEERS

1 Electrical
1 Mechanical

NEEDED NOW

● WANTED as assistants to Chief Engineer of long-established, international organization.

The right men, with either or both electrical and mechanical engineering and design experience and demonstrated creative ability in the development of machine products for industry, will command good salaries.

The positions are with an alert and progressive manufacturer now engaged in vital war work and long recognized as a peacetime leader in its field.

Congenial working conditions in a pleasant community forty miles from Chicago. Send us your complete background; we will hold it in strictest confidence.

P-586, Electronics
520 N. Michigan Ave., Chicago 11, Ill.

HELP WANTED

ELECTRONIC ENGINEERS
MECHANICAL ENGINEERS
METALLURGICAL ENGINEERS
with
Knowledge of Electronics
Licensed Radio Operators
to work with a
Modern Television Concern
presently devoting
100% of its efforts to
National Defense

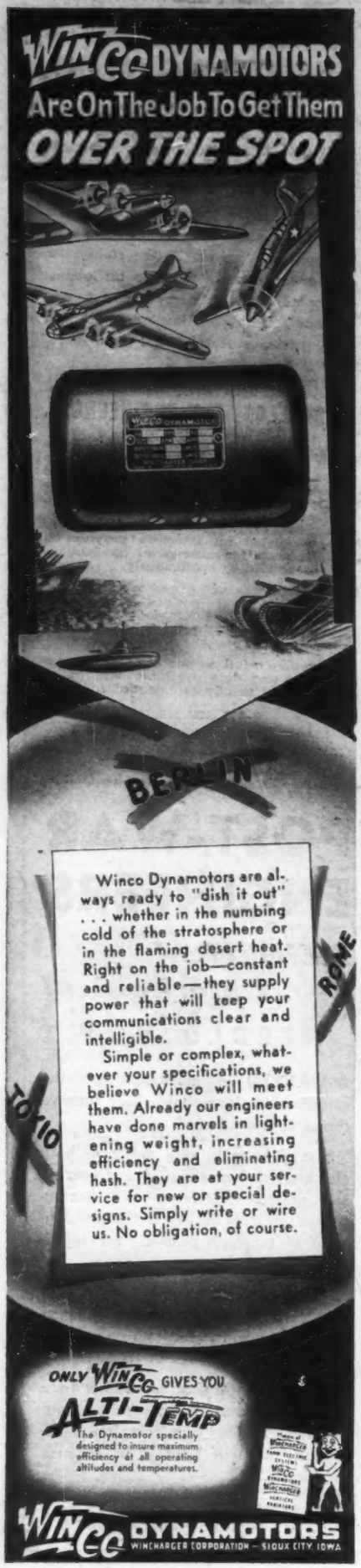
Allen B. Du Mont Laboratories, Inc.
2 Main Ave., Passaic, N. J.

WANTED

ENGINEERS—ELECTRICAL

With experience on small motor-driven appliances or small motors
or
Experience in electronics as applied to small industrial accessories.
Excellent opportunity to join growing organization doing essential war work in aircraft and having good postwar prospects.
Location northern Ohio.
Certificate of availability required.
Our employees know about this advertisement.

P-576, Electronics
520 No. Michigan Ave., Chicago 11, Ill.


WINCO DYNAMOTORS
Are On The Job To Get Them
OVER THE SPOT
BERLIN
ROME
TOKIO
Winco Dynamotors are always ready to "dish it out" . . . whether in the numbing cold of the stratosphere or in the flaming desert heat. Right on the job—constant and reliable—they supply power that will keep your communications clear and intelligible.
Simple or complex, whatever your specifications, we believe Winco will meet them. Already our engineers have done marvels in lightening weight, increasing efficiency and eliminating hash. They are at your service for new or special designs. Simply write or wire us. No obligation, of course.
ONLY WINCO GIVES YOU
ALTI-TEMP
The Dynamotor specially designed to insure maximum efficiency at all operating altitudes and temperatures.
WINCO DYNAMOTORS
WINCHARGER CORPORATION – SIOUX CITY, IOWA

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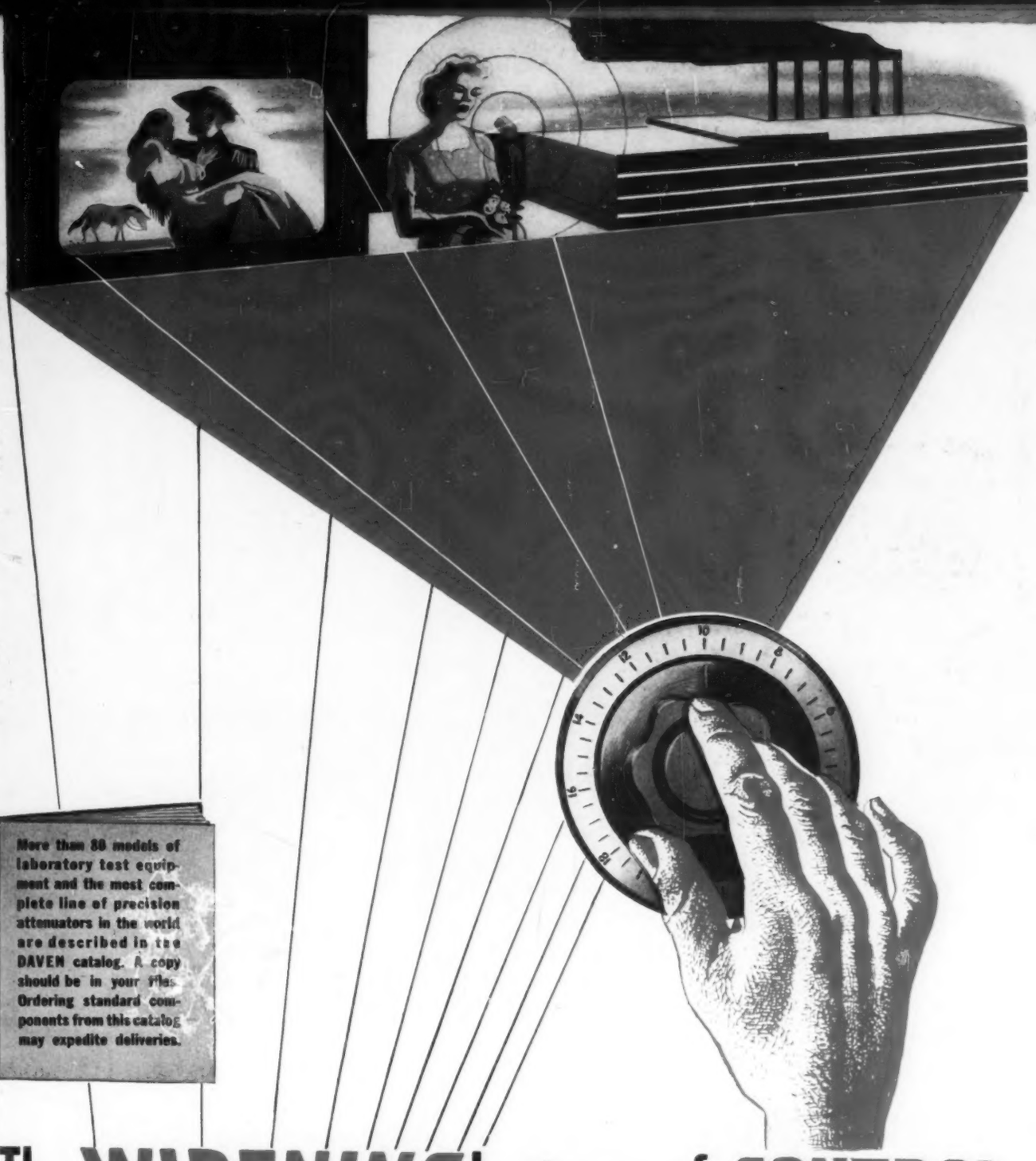


More than 80 models of laboratory test equipment and the most complete line of precision attenuators in the world are described in the DAVEN catalog. A copy should be in your files. Ordering standard components from this catalog may expedite deliveries.

The WIDENING horizons of CONTROL

DAVEN attenuators have successfully served the leaders in the broadcast, sound picture, television and electrical fields for many years. They are preferred components because precise and absolute control is provided. Now, new industrial electronic applications . . . many currently used and others being developed for postwar . . . widen the horizons of control. Here, too, DAVEN attenuators may be depended upon for accuracy, efficiency, durability.

KEEP BUYING MORE AND MORE WAR BONDS

THE DAVEN COMPANY

191 CENTRAL AVENUE NEWARK 4, NEW JERSEY

"Give Us Tubes That Last Longer"... Is The Cry

AND RCA ENGINEERS ARE DOING IT!

RCA 872-A / 872

Half-Wave Mercury Vapor Rectifier

$7.50

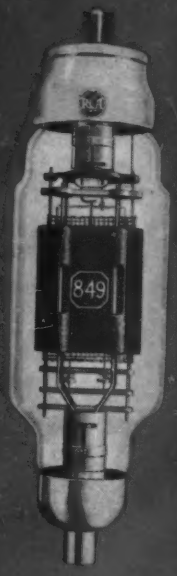
Replacing the 872 and 872-A, this new tube gives you better results for less money. A special alloy for the cathode base yields increased emission with lower tube drop, enables the tube to withstand larger surge currents without injury to cathode coating. And thermal efficiency has been greatly increased. Net result: better performance, longer life. (Note: RCA 8008 is a companion tube similar to type 872-A/872. The electrical specifications of each are identical. Type 8008 is equipped with heavy duty base and is particularly recommended for use in new equipment.) RATINGS: Filament Voltage, 5 volts; Filament Current, 7.5 amperes; Peak Inverse Voltage, 10,000 volts, max.*; Peak Plate Current, 5 amperes, max.; Average Plate Current, 1.25 amperes, max.

*For condensed-mercury temperature of 20-60° C.

RCA 849

R-F and A-F Power-Amplifier, Oscillator, Modulator

$120



The real value that tube users get from many tube-engineering improvements largely depends upon the manner in which the improvements are utilized in the overall designs. For example, the famous RCA zirconium-coated anode, used in the RCA-849, could have been applied primarily to the purpose of giving this tube a greatly increased rating. Or it could be utilized as RCA has done—to produce a tube which, operated at a conservative rating, would yield a very considerable increase in the operating life of the tube. In these days, dependable performance, plus long tube life, is most needed. And that is exactly what you get with the long-service RCA-849. RATINGS: Filament Voltage, 11 volts; Filament Current, 5 amperes; Plate Voltage, 2500 volts, max.*; Plate Dissipation, 400 watts, max.*

*For Class C telegraph service.

RCA 828

Beam Power Amplifier

$17.50

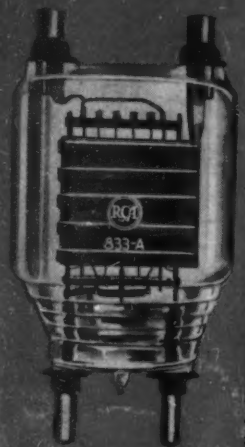
High output with extremely low driving power is the big feature of RCA 828. And in addition, this tube needs no neutralizing in well-shielded circuits. In ICAS class C telegraph service, the 828 will *deliver* 200 watts with only 2.2 watts driving power! Conservatively operated at CCS ratings, the RCA 828 provides high safety factor and long life. Its high power-sensitivity saves vital materials by eliminating intermediate amplifier stages. Maximum frequency—30 mc at full rating; 75 mc at reduced rating. RATINGS: Filament Voltage, 10 volts; Filament Current, 5.25 amperes; plate voltage, 1250 volts, max.*; Screen Voltage, 400 volts, max.*; Plate Dissipation, 70 watts, max.*

*CCS rating for Class C Telegraph service.

RCA 833-A

Transmitting Triode

$76.50



An outstanding feature of this high-power air-cooled triode is its famous RCA zirconium-coated anode, permitting 44% more input and 33% more plate dissipation under CCS conditions than were possible with its predecessor, the 833. Designed for use as an r-f amplifier, class B modulator, and oscillator. This is one of RCA's most powerful glass-type triodes. Built for long life. RATINGS: Filament Voltage, 10 volts; Filament Current, 10 amperes; Amplification factor, 36; D-C Plate Voltage, 4,000 volts, max.*; Plate Current, 500 milliamperes, max. Plate Dissipation, 400 watts, max.*

*CCS rating with forced-air cooling for Class C telegraph service.

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